Notice No. 4

Rules and Regulations for the Classification of Naval Ships, January 2015

The status of this Rule set is amended as shown and is now to be read in conjunction with this and prior Notices. Any corrigenda included in the Notice are effective immediately.

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Amendments to	Effective Date
Volume 2, Part 1, Chapter 1, Sections 2, 3, 4, 5, 8 & 9	1 January 2016
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Volume 2, Part 1, Chapter 3, Sections 1, 3, 4, 6, 7 & 17	1 January 2016
Volume 2, Part 1, Chapter 5, Section 1	1 January 2016
Volume 2, Part 2, Chapter 1, Sections 1 to 15	1 January 2016
Volume 2, Part 2, Chapter 2, Scope and Sections 1, 3, 5, 7 & 9	1 January 2016
Volume 2, Part 2, Chapter 3, Section 1	1 January 2016
Volume 2, Part 3, Chapter 1, Section 9	1 January 2016
Volume 2, Part 3, Chapter 2, Sections 4 & 5	1 January 2016
Volume 2, Part 4, Chapter 2, Section 2	1 January 2016
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Volume 2, Part 5, Chapter 1, Sections 1 & 3	1 January 2016
Volume 2, Part 5, Chapter 4, Section 2	1 January 2016
Volume 2, Part 6, Chapter 1, Section 5	1 January 2016
Volume 2, Part 7, Chapter 1, Sections 2, 3, 5, 9, 11 & 12	1 January 2016
Volume 2, Part 7, Chapter 2, Sections 6, 10 & 11	1 January 2016
Volume 2, Part 7, Chapter 3, Sections 1, 3, 6, 7, 8, 9 & 12	1 January 2016
Volume 2, Part 7, Chapter 5, Sections 1, 3, 4, 7 & 11	1 January 2016
Volume 2, Part 8, Chapter 1, Section 15	1 January 2016
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Volume 2, Part 9, Chapter 2, Sections 2, 4 & 7	1 January 2016
Volume 2, Part 9, Chapter 3, Sections 2, 4, 5, 6, 7, 8 & 10	1 January 2016
Volume 2, Part 9, Chapter 4, Sections 4 & 6	1 January 2016
Volume 2, Part 9, Chapter 7, Scope and Sections 1, 2 & 4	1 January 2016
Volume 2, Part 9, Chapter 8, Scope and Section 5	1 January 2016
Volume 2, Part 9, Chapter 9, Sections 2 & 5	1 January 2016
Volume 2, Part 9, Chapter 11, Section 1	1 January 2016
Volume 2, Part 10, Chapter 1, Sections 6 & 7	1 January 2016
Volume 2, Part 11, Chapter 1, Section 3	1 January 2016
Volume 2, Part 12, Chapter 1, Sections 1 to 7	1 January 2016

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Volume 2, Part 1, Chapter 1

General Requirements for Classification of Engineering Systems

Effective date 1 January 2016

■ *Section 2*
Engineering system classification provisions

2.1 Provisions

(*Part only shown*)

2.1.1 The classification provisions for engineering systems installed in naval ships address the following:

(a) The suitability and functioning of equipment and systems for maintaining the watertight and weathertight integrity of the hull, and spaces within the hull.

(b) The safety and reliability of engineering systems necessary for propulsion~~,~~ and steering and other ~~essential~~ engineering systems falling within the Mobility or Ship Type categories.

■ *Section 3*
Engineering system designation

3.1 Categories

3.1.2 Mobility category engineering systems are those systems installed in order for the ship to proceed on operations and are necessary for:

(a) ~~The~~ Maintaining the watertight and weathertight integrity of the hull and spaces within the hull.

(b) The safety and reliability of propulsion, steering ~~and other essential auxiliary engineering~~ and electrical systems.

(c) The operation and functioning of emergency machinery and equipment.

3.1.3 Ship Type category engineering systems are those systems installed in order for the ship to carry out its in-service purpose and are necessary for:

(a) The operation and functioning of the systems and equipment installed for purposes relating to the ~~ship type~~ ship's in-service purpose excluding the operation and functioning of military systems.

(b) The operation and functioning of emergency machinery and equipment.

~~3.1.5 Essential services are those necessary for the propulsion and safety of the ship within the Mobility and Ship Type categories defined in Vol 2, Pt 1, Ch 1, 3.1 Categories and Vol 2, Pt 1, Ch 1, 3.1 Categories and include but are not limited to the following:~~

- ~~air compressors for oil engines;~~
- ~~air pumps;~~
- ~~automatic sprinkler systems;~~
- ~~ballast pumps;~~
- ~~bilge and dewatering system pumps;~~
- ~~circulating and cooling water pumps;~~
- ~~communication systems;~~
- ~~condenser circulating pumps;~~
- ~~electric propulsion equipment;~~
- ~~electric starting systems for oil engines;~~
- ~~extraction pumps;~~
- ~~fans for forced draught to boilers;~~
- ~~feed water pumps;~~
- ~~fire detection and alarm systems;~~
- ~~fuel valve cooling pumps;~~
- ~~hydraulic pumps for controllable pitch propellers and those serving essential services here listed that would otherwise be directly electrically driven;~~
- ~~lubricating oil pumps;~~
- ~~lighting systems for those parts of the ship normally accessible to and used by personnel;~~
- ~~made and clean water equipment;~~
- ~~navigational aids~~
- ~~navigation lights and special purpose lights~~
- ~~fuel oil pumps and fuel oil burning units;~~
- ~~oil separators;~~
- ~~pumps for fire-extinguishing systems;~~

- ~~scavenge blowers;~~
- ~~steam raising plant, where steam is required for other essential services;~~
- ~~steering gear;~~
- ~~valves which are required to be remotely operated;~~
- ~~ventilating fans for engine and boiler rooms;~~
- ~~watertight doors, shell doors and other electrical operated closing appliances;~~
- ~~windlasses;~~
- ~~power sources and supply systems for supplying the above services.~~

~~Essential military systems and damage control arrangements relating to the Ship Type are to be stated where applicable.~~

3.1.5 Engineering Systems are to be assigned to the appropriate category taking into consideration the:

- ConOps for the vessel (*see* Vol 1, Pt 1, Ch 2, 2.2.15);
- criteria in paragraphs 3.1.1 to 3.1.4 for Engineering Systems and the Mobility, Ship Type and Ancillary categories;
- dependency of Mobility or Ship Type engineering system upon other systems or services for their correct operation. (E.g. if the propulsion plant's electronic control systems is cooled by chilled water, then the chilled water system is to be considered critical to the propulsion plant's function and assigned to the Mobility category);
- military systems and damage control arrangements relating to the Ship Type are to be stated where applicable.

■ *Section 4*
Engineering system classification principles

4.5 Trials principles

(*Part only shown*)

4.5.4 Where a Risk Assessment report, (*see* Vol 2, Pt 1, Ch 3, 17 Risk Assessment (RA)), has identified the need to prove the conclusions, testing and trials are to be carried out as necessary to investigate the following:

(c) The behaviour of any interlocks that may inhibit operation of ~~essential services~~ Mobility or Ship Type systems.

■ *Section 5*
Acceptance criteria

5.1 Acceptance

(*Part only shown*)

Table 1.5.1 Assessment process for engineering systems

/	**SYSTEM**	**MOBILITY CATEGORY**	**SHIP TYPE CATEGORY**	**ANCILLARY CATEGORY**
PROCESS	**/**			
IN SERVICE		• Subject to survey by the Rules or Regulations	• Subject to survey where required by the Rules or Regulations or requested by Owners or Naval Administration	• ~~No requirements unless required~~ • General examination
MODIFICATIONS		• Details of modifications are to be approved by LR • Construction, installation and trials are to be carried out under survey	• Details of any modifications are to be approved and construction, installation and trials are to be carried out under survey when not required by the Rules or Class notation	• Details of any modifications are to be recorded to enable review by LR Surveyors • Modifications are to be reviewed to ensure they do not change the category of the system

■ *Section 8*
Quality assurance scheme for machinery

Existing Section 8 *has been deleted in its entirety.*

8.1 General

8.1.1 The Quality Assurance Scheme for Machinery (QAM Scheme) is an alternative to direct survey and certification of machinery components and equipment required by the Rules. Under the QAM Scheme LR will consider the extent to which manufacturing processes and control procedures ensure conformity of that machinery to Rules, technical specifications and any other applicable standards or codes.

8.1.2 This QAM Scheme is applicable to items manufactured under closely controlled conditions. A list of products for which the QAM Scheme is applicable is provided in LR's *ShipRight Procedure Approval of a Manufacturer according to the Quality Assurance Scheme for Machinery*.

8.1.3 The QAM Scheme does not reduce the test requirements to be carried out in accordance with LR's Rules.

8.2 Definitions

8.2.1 The following definitions apply in the context of this Section:

8.2.2 QAM Scheme audit
An audit, conducted by LR at the manufacturer's, or their supplier's or sub-contractor's works, of their products and/or processes, which may include direct survey, in order to provide confidence that products are manufactured, tested and inspected in accordance with LR's Rules. Periodicity of surveillance audits is as agreed in the QAM Scheme Certification Schedule, *see* LR's *ShipRight Procedure Approval of a Manufacturer according to the Quality Assurance Scheme for Machinery*.

8.2.3 Assessment
A review, conducted by LR, of evidence gained through a number of sources, such as documentation, submitted by the manufacturer or supplier or sub-contractor, and regular QAM Scheme audit reports, in order to verify that products are manufactured, tested and inspected in accordance with the Rules.

8.2.4 Manufacturer
A company that contracts to supply components or equipment products to a customer or user and applies for approval under the QAM Scheme.

8.2.5 Supplier
A company that contracts to supply materials, components or equipment products to the Manufacturer applying for approval under the QAM Scheme.

8.3 QAM Scheme Arrangements

8.3.1 A manufacturer may apply to be approved under the QAM Scheme where the following requirements are met:
(a) The manufacturer has a quality management system which has been certified as meeting the requirements of ISO 9001, or industry-specific equivalent standard, by a certification body accredited by a member of the International Accreditation Forum and recognised by LR.
(b) The manufacturer has processes in place suitable for the products to be certified under the QAM Scheme.
(c) The manufacturer has a satisfactory and documented history of quality performance in the supply of products for which certification under the QAM Scheme is requested.

8.3.2 The scope and arrangements for survey, identification and certification of products covered by the QAM Scheme are to be agreed with LR and will be detailed in a Scheme Certification Schedule. The Survey will be based on a technical audit approach, focussing on product realisation. Direct survey may also be used where it is considered appropriate to do so.

8.3.3 The QAM Scheme procedures given in LR's *ShipRight Procedure Approval of a Manufacturer according to the Quality Assurance Scheme for Machinery* are to be complied with.

8.3.4 Where LR is satisfied that the manufacturer meets all of the requirements of the QAM Scheme, and that it is appropriate for the products being manufactured, LR will issue the manufacturer with a QAM Scheme Certificate which will list products covered.

8.3.5 LR reserves the right to carry out unscheduled audits, with appropriate notice, at the manufacturer's works or their suppliers' and sub-contractors' works.

8.3.6 Once every three years, a full re-certification assessment of QAM Scheme compliance, including an audit of the manufacturer's works, will be conducted by LR.

Volume 2, Part 1, Chapter 1

8.3.7 The manufacturer is to advise LR of changes to the product, processes or suppliers or sub-contractors which would affect compliance with the QAM Scheme or LR's Rules. Any deviations from the approved plans or specifications are to be reported to LR and written approval obtained prior to dispatch of the items.

8.3.8 Where it is considered that the manufacturer no longer meets the approval requirements for the QAM Scheme, the QAM Scheme Certificate will be suspended. In these circumstances, the manufacturer will be notified in writing of LR's reasons for suspension of the scheme and the manufacturer will revert to direct survey and issue of LR certificates.

8.3.9 **QAM Scheme product certificates.** Where the manufacturer is approved according to the QAM Scheme, they will be entitled to issue 'QAM Scheme product certificates'. These certificates are to clearly detail the product being certified and are to be validated by an authorised representative of the manufacturer. The certificates are to be countersigned by LR to certify that the Rule requirements for that product are being met.

8.4 Acceptance of purchased materials, components and equipment

8.4.1 The manufacturer is to establish and maintain procedures and controls to ensure compliance with LR's requirements for certification of products from its suppliers. The manufacturer is to ensure that purchased products that are required to be certified in accordance with Chapters 3 to 10 of the Rules for Materials are made at works which have been approved by LR for the type and grade of product being supplied. The manufacturer's system for control of purchased products is to be based on one or a combination of the following alternatives:

(a) Product certification by LR at the supplier's works in accordance with the requirements of the Rules.
(b) Product certification by a supplier separately approved by LR under the QAM Scheme or other LR Quality Scheme covering those products.
(c) Product certification by the manufacturer in accordance with quality processes for control of suppliers of purchased products included within the scope of the manufacturer's QAM Scheme approval. These quality schemes are to ensure compliance with Rule requirements for the purchased products.

8.4.2 **Manufacturers' certificates issued under the QAM Scheme.**
Where the manufacturer's system for control of purchased products from suppliers is based on Vol 2, Pt 1, Chapter 1, 8.4.1(c) and Surveyors have confirmed that LR Rules are being satisfied, the manufacturer will be permitted to accept 'Manufacturers' certificates issued under the QAM Scheme', in lieu of LR Certificates for purchased products. The certificates must bear the QAM Scheme mark and the following statement:

'This certificate is issued under the arrangements authorised by Lloyd's Register (operating entity, e.g. EMEA) in accordance with the requirements of the Quality Assurance Scheme for Machinery and Scheme number, QAM……..'

■ *Section 9*
Type approval system (for information)

9.1 General

(*Part only shown*)
9.1.3 Details of LR's Type Approval System are contained in the following LR publications:
(e) Test Specification 4: *Type Testing of Reciprocating Internal Combustion Engines and Associated Ancillary Equipment*.

Volume 2, Part 1, Chapter 2

Requirements for Machinery and Engineering Systems of Unconventional Design

Effective date 1 January 2016

■ *Section 1*
Requirements for machinery and engineering systems of unconventional design

1.7 Risk management

(*Part only shown*)
1.7.1 A risk management procedure is to be established in order to ensure that any risks stemming from the introduction of the machinery or engineering system are addressed, in particular risks affecting:
(d) The reliability of ~~essential and~~ Mobility systems, Ship Type systems, emergency machinery and engineering systems.

Volume 2, Part 1, Chapter 3

Requirements for Design, Construction, Installation and Sea Trials of Engineering Systems

Effective date 1 January 2016

■ *Section 1*
Scope

1.1 Application

(*Part only shown*)
1.1.1 This Chapter applies to the design, construction, installation and testing of Mobility, Ship Type, and Ancillary category engineering systems for classed naval ships and covers:

- ~~Essential auxiliary~~ Auxiliary machinery systems.

■ *Section 3*
Documentation required for design review

3.3 Calculations and specifications

(*Part only shown*)
3.3.7 A Risk Assessment (RA), in accordance with the guidance in Vol 2, Pt 1, Ch 3, 17 Risk Assessment (RA), is to be carried out, covering the following systems:
(a) Main and auxiliary machinery systems supporting propulsion, steering, ~~or other essential services~~ Mobility systems or Ship Type systems.

3.4 System Operational Concept

(*Part only shown*)
3.4.3 The System Operational Concept is to include the following information, as appropriate to the system:

- Reference to the relevant requirements derived from the Concept of Operations;
- Operating modes and philosophy, including reversionary and emergency modes recognising the operational and manning philosophy for the vessel;
- Describe the designer’s intent and the criticality of particular system features or equipment (with particular reference to those elements required to maintain ~~essential services~~ Mobility and/or Ship Type systems and those installed for capability only);
- Justify non-compliances with the Rules due to the system design and functionality (e.g. black start requirements applied to designated engines only);
- Information required to be included by the individual Chapters.

■ *Section 4*
Operating conditions

4.4 Ambient reference conditions

(*Part only shown*)
4.4.1 The rating for classification purposes of main and ~~essential~~ auxiliary machinery intended for installation in Mobility or Ship Type systems in naval seagoing ships to be classed for unrestricted (geographical) service is to be based on:

4.5 Ambient operating conditions

4.5.1 Main and ~~essential~~ auxiliary machinery and equipment ~~is~~ in Mobility or Ship Type systems are to be capable of operating satisfactorily under the conditions shown in Table 3.4.1 Ambient operating conditions.

4.6 Inclination of ship

4.6.1 Main and ~~essential~~ auxiliary machinery in Mobility, Ship Type systems, electrical and emergency equipment ~~is~~ are to operate satisfactorily under the conditions as shown in Table 3.4.2 Inclinations.

Table 3.4.2 Inclinations

Engineering installations and equipment	Angle of inclination, degrees (*see* Note 1)			
	Athwartship		Fore-and-aft	
	Static(Heel)	Dynamic(Roll)	Static(Trim)	Dynamic(Pitch)
Main and auxiliary machinery ~~essential to the propulsion and safety of the ship~~ in Mobility and Ship Type Systems including ~~essential~~ electrical equipment	15	±22,5	5 (*see* Note 2)	±7,5
Emergency machinery and equipment including electrical equipment. Switchgear, electrical and electronic appliances (*see* Note 3) and remote control systems	22,5 (*see* Note 4)	±22,5	10	±10

Note 1. Athwartships and fore-and-aft inclination may occur simultaneously.
Note 2. Where the length of the ship exceeds 100 m, the fore-and-aft static angle of inclination may be taken as 500/*L* degrees where *L* = length of ship, in metres.
Note 3. Up to an angle of inclination of 45 degrees no undesired switching operations or operational changes may occur.
Note 4. A static damaged condition up to a maximum of 30 degrees may be required by the specified standards.

4.11 Machinery shock arrangements

(*Part only shown*)

4.11.2 A shock System Design Description, may be specified by the Owner. The System Design Description is to identify the level of shock resistance for installed machinery, engineering systems and equipment and is to address:

(a) Protection of the crew and embarked personnel.
(b) The capability of machinery, equipment and systems to operate after shock loading.
(c) The capability of securing arrangements to retain machinery and equipment captive after shock loading.
(d) The location of machinery/equipment and routing of ~~essential~~ Mobility and/or Ship Type electrical and piping systems to maintain services in the event of damage due to shock loading.

4.13 Electromagnetic compatibility (EMC)

4.13.1 Propulsion, steering, navigation and other ~~essential~~ Mobility and/or Ship Type systems, including weapons systems are to be designed and installed such that their performance does not degrade from the manufacturer's specifications as a result of susceptibility to electromagnetic interference generated during both normal operation and during military activities.

4.15 Stopping of machinery

4.15.1 Diesel engines, gas and steam turbines, other prime movers, ~~and essential services~~ Mobility systems and Ship Type systems are to be provided with a means of emergency stop, capable of being activated at a position outside the compartment in which the machinery is located. The arrangements are to be fully independent of control and alarm systems, and are to ensure a safe and controlled shutdown of machinery. Where such arrangements depend upon programmable electronic equipment, they are to comply with the relevant requirements in Vol 2, Pt 9, Ch 8, 5.4 Additional requirements for Mobility category and safety critical systems

■ *Section 6*
~~Diesel engines~~ Reciprocating internal combustion engines

6.1 Design and testing

6.1.2 For details of materials and component testing requirements, *see* Vol 2, Pt 2, Ch 1, 3 Materials.

6.1.3 For details of engine type testing requirements, *see* Vol 2, Pt 2, Ch 1, 12 Mass produced turbochargers and LR's Type Approval Test Specification No. 4 – *Type Testing of Reciprocating Internal Combustion Engines and Associated Ancillary Equipment*.

Existing sub-Section 6.3 *has been renumbered sub-Section* 3.3 *in* Vol 2, Pt 2, Ch 1.

Existing sub-Section 6.5 *has been renumbered sub-Section* 3.5 *in* Vol 2, Pt 2, Ch 1.

Existing sub-Sections 6.4 *and* 6.6 *have been deleted*.

Volume 2, Part 1, Chapter 3

■ *Section 7*
Turbochargers

7.1 Design and testing

7.1.2 For details of testing requirements, *see* Pt 2, Ch 1, 11 Mass produced engines.

Existing sub-Section 7.2 *has been deleted*.

Existing sub-Sections 7.3 *to* 7.5 *have been renumbered sub-Sections* 11.2 *to* 11.4 *in* Vol 2, Pt 2, Ch 1.

Existing sub-Section 7.5 *has been deleted*.

■ *Section 17*
Risk Assessment (RA)

17.1 General

17.1.2 The RA is to demonstrate that suitable risk mitigation has been achieved for all normal and reasonably foreseeable abnormal conditions. The scope of analysis required for each system is defined in Vol 2, Pt 1, Ch 3, 17.1 General and in the respective parts of the Rules.

Note A reasonably foreseeable abnormal condition is an event, incident or failure that:

- has happened and could happen again;
- has not happened but is considered possible. Where the likelihood is considered extremely unlikely or the consequences are trivial, and no further prevention or mitigation action is to be taken, then this is to be justified;
- is planned for (e.g. emergency actions cover such a situation, maintenance is undertaken to prevent it, etc.).

Note ~~They~~ These conditions should be identified by:

- using analysis processes that ~~were~~ are capable of revealing abnormal conditions;
- employing a mix of personnel including: designers, operators, persons who carry out maintenance, those with relevant domain knowledge and understanding, and competent safety/risk professionals ~~and those with relevant domain knowledge and understanding~~ to apply the processes;
- referencing relevant events and historic data; and
- documenting the results of the analysis.

Volume 2, Part 1, Chapter 5

Spare Gear for Machinery Installations

Effective date 1 January 2016

■ *Section 1*
General

1.1 Application

1.1.1 Adequate spare parts for the propelling and ~~essential~~ auxiliary machinery for Mobility systems and Ship Type systems, together with the necessary tools for maintenance and repair shall be readily available for use.

Volume 2, Part 2, Chapter 1

~~Diesel~~ Reciprocating Internal Combustion Engines

Effective date 1 January 2016

■ *Section 1*
General ~~Requirements~~ requirements

1.1 Application

1.1.2 The requirements of this Chapter are applicable to reciprocating internal combustion engines operating on liquid, gas or dual fuel for use in Mobility or Ship Type systems (hereinafter referred to as engines). The requirements of Vol 2, Pt 2, Ch 1, 4 Crankshaft design do not apply to ~~diesel~~ engines intended for ~~essential services~~ Mobility or Ship Type systems where power does not exceed 110 kW.

1.1.4 For the purposes of this Chapter engine type, expressed by the manufacturer/licensor’s designation, is defined by:

(a) the bore and stroke;
(b) the method of injection (i.e. direct injection, indirect injection, pilot injection);
(c) the fuel pump and injection system (independent line to fuel oil valve, common rail);
(d) the valve and injection operation (by cams or electronically controlled);
(e) the fuel(s) used (liquid, dual-fuel, gaseous, etc.);
(f) the working cycle (4-stroke, 2-stroke);
(g) the gas exchange (naturally aspirated, turbocharged, etc.);
(h) the method of turbocharging (pulsating system, constant pressure system);
(i) the charging air cooling system (with or without intercooler, number of stages);
(j) cylinder arrangement (in-line, vee, etc.);
(k) the maximum continuous power per cylinder (or maximum continuous brake mean effective pressure) at maximum continuous speed;
(l) the manufacturer and type of governor (and control system if applicable) fitted.

1.1.5 A complete engine includes the control system, turbocharger(s) and all ancillary systems and equipment referred to in this Chapter that are used for operation of the engine for which there are rule requirements; this includes systems allowing the use of different fuel types.

1.4 Inclination of ship

1.4.1 Main and ~~essential~~ auxiliary ~~diesel~~ engines for Mobility systems or Ship Type systems are to operate satisfactorily under the conditions as shown in Table 3.4.2 Inclinations.

~~1.5 Engine type testing~~

Existing paragraph 1.5.1 *has been renumbered* 12.1.1*.*

~~1.6~~ 1.5 Turning gear

Existing paragraph 1.6.1 *has been renumbered* 1.5.1.

~~1.6.2~~ 1.5.2 The turning gear for all propulsion engines is to be power-driven and ~~if electric,~~ is to be continuously rated at a value to ensure protection to the weakest part of the machinery.

Existing paragraphs 1.6.3 *to* 1.6.7 *have been renumbered* 1.5.3 *to* 1.5.7*.*

■ *Section 2*
Documents required for design review

2.1 Approval process

2.1.1 Approval of an engine type will be granted following:

(a) satisfactory design appraisal. Plans are to be submitted as required in Table 1.2.1 Plans and particulars to be submitted.

(b) satisfactory type testing (*see* Vol 2, Pt 2, Ch 1, 12.1 Application).

Note: Approval of the engine type is not to be confused with LR Type Approval; LR Type Approval is explained in Vol 1, Pt 1, Ch 2, 5.1 LR Type Approval and Vol 2, Pt 1, Ch 1, 9 Type approval system (for information).

2.1.2 Each complete engine, as defined in Vol 2, Pt 2, Ch 1, 1.1.5, intended for installation on an LR Classed vessel, is to have an LR Engine Certificate.

2.1.3 For the first engine of a type the approval process and the engine certification process may be performed simultaneously.

2.1.4 To apply for an LR Engine Certificate, the following are to be submitted:

(a) a list of all documents identified in the ‘for information’ and ‘for appraisal’ columns of Table 1.2.1 Plans and particulars to be submitted with the relevant drawing numbers and revision status. This list is to cross-reference the approved plans previously submitted in accordance with Vol 2, Pt 2, Ch 1, 2.1.1(a) and identify any plans that have been modified.

(b) where there is a licensor/licensee arrangement the list required by Vol 2, Pt 2, Ch 1, 2.1.4(a) is to cross-reference the drawings submitted by the designer in accordance with Vol 2, Pt 2, Ch 1, 2.1.1(a). This list is to identify all changes where the approved design has been modified by the licensee. Where the licensee proposes design modifications to components, a statement is to be made confirming the licensor’s acceptance of the proposed changes. If designer/licensor’s acceptance is not confirmed, the engine is to be regarded as a different type and is subject to the complete appraisal and type testing process.

(c) all documents with changes from the approved design are to be submitted for review/appraisal.
In all cases the complete set of endorsed documents and the list referenced in Vol 2, Pt 2, Ch 1, 2.1.4(a), which are to be provided by the manufacturer, will be required by the Surveyor(s) attending the manufacturer’s works. Where a licensee/licensor arrangement is in place, this set of documents may be a combination of licensor and licensee documents.

2.1.5 An LR Engine Certificate is issued upon satisfactory completion of engine assembly, with associated component testing (*see* Vol 2, Pt 2, Ch 1, 3 Materials and components) and factory acceptance testing (*see* Vol 2, Pt 2, Ch 1, 10 Factory Acceptance Test and Shipboard Trials of Internal Combustion Engines). An alternative method of engine certification is available to manufacturers approved under the Quality Assurance Scheme for Machinery (QAM). *See* Vol 2, Pt 1, Ch 1, 8 Quality assurance scheme for machinery.

2.1.6 For appraisal of emergency generator sets and turbochargers additional submissions are required. *See* Vol 2, Pt 2, Ch 1, 2.2.3 and 2.2.4 as applicable.

2.1.7 Where required materials and components are to be manufactured, tested and certified at a manufacturer approved by LR in accordance with the Rules for the Manufacture, Testing and Certification of Materials (hereinafter referred to as Rules for Materials), *see* Vol 2, Pt 2, Ch 1, 3 Materials and components.

~~2.1 Documentation~~

Existing paragraphs 2.1.1 *to* 2.1.3 *have been deleted.*

Existing paragraph 2.1.4 *has been renumbered* 2.3.2*.*

Existing paragraphs 2.1.5 *to* 2.1.6 *have been deleted.*

Existing paragraph 2.1.7 *has been renumbered* 2.2.6.

2.2 Submission requirements

Table 1.2.1 Plans and particulars to be submitted

Document	For information	For appraisal
	(X *indicates reason for submission)*	
Engine particulars (LR Form 2073 with general engine and ancillaries information, Project Guide, Marine Installation Manual) (*See* Note 1)	X	
Material specifications of principal components with information on non-destructive material tests and pressure tests		X
Engine cross-section	X	
Engine longitudinal section	X	
Engine frames, welding drawings (*See* Notes 2 and 3)		X
Main engine foundation and holding down and securing arrangements	X (metal chocks)	X (non-metallic chocks)
Bedplate and crankcase of cast design	X	
Bedplate and crankcase of welded design, with welding details and welding instructions (*See* Notes 2 and 3)		X
Bedplate/oil sump welding drawings (*See Note* 2)		X
Thrust bearing assembly (*See* Note 4)	X	
Thrust shaft or intermediate shaft (if integral with engine)		X
Thrust bearing bedplate of welded design, with welding details and welding instructions (*See* Note 2)		X
Frame (*See* Note 3), framebox (*See* Note 3) and gearcase of cast construction	X	
Tie rod	X	
Connecting rod, assembly (*See* Note 5)	X	
Crosshead, assembly (*See* Note 5)	X	
Piston rod, assembly (*See* Note 5)	X	
Piston, assembly (*See* Note 5)	X	
Piston head	X	
Cylinder jacket/ block of cast construction (*See* Note 3)	X	
Cylinder cover, assembly (*See* Note 5)	X	
Cylinder liner	X	
Counterweights (if not integral with crankshaft), including fastening	X	
Crankshaft, details (for each crankthrow)		X
Crankshaft, assembly (for each crankthrow)		X
Crankshaft calculations (*See* Vol 2, Pt 2, Ch 1, 4 Crankshaft design)	X	
Camshaft drive, assembly (*See* Note 5)	X	
Flywheel or turning-wheel	X	
Shaft coupling interface arrangement including dimensions and material details		X
Details of shielding and insulation of exhaust pipes and other parts operating at an elevated temperature, which might be impinged by flammable fluid(s) as a result of a system failure	X	

Details of shielding and insulation of exhaust pipes and other parts operating at an elevated temperature, which might be impinged by flammable fluid(s) as a result of a system failure	X	
Schematic layout or other equivalent documents for the engine: (*See* Note 6)		
• Starting and control air systems		X
• Fuel system		X
• Lubricating oil system		X
• Cooling water system		X
• Hydraulic systems		X
• Engine control and safety system		X
High pressure fuel injection pump assembly	X	
High pressure parts for fuel oil injection system (*See* Note 7)		X
Shielding arrangements for high pressure piping - fuel, hydraulic and flammable oils (*See* Vol 2, Pt 2, Ch 1, 8.1.4)		X
Fastening arrangements for main bearings	X	
Fastening arrangements for cylinder heads and exhaust valve (two stroke design)	X	
Fastening arrangements for connecting rods	X	
Vibration dampers/detuners and moment compensators	X	
Construction and arrangement of vibration dampers	X	
Details of mechanical joints of piping systems		X
Oil mist detection and/or alternative arrangements		X
Construction of accumulators (common rail) for electronically controlled engine		X
Construction of common accumulators (common rail) for electronically controlled engine		X
Construction of accumulators for hydraulic oil and fuel oil		X
Arrangement and details of the crankcase explosion relief valve where applicable (*See* Vol 2, Pt 2, Ch 1, 10 Factory Acceptance Test and Shipboard Trials of Internal Combustion Engines)		X
Calculation results for crankcase explosion relief valves (*See* Vol 2, Pt 2, Ch 1, 10 Factory Acceptance Test and Shipboard Trials of Internal Combustion Engines)		X
Construction and arrangements of hydraulic systems for actuation of sub-systems:		
• Control valves, high-pressure pumps, pipes and accumulators	X	
• Drive for high pressure pumps	X	
• Valve bodies, if applicable	X	
For engine control, alarm monitoring and safety systems, the plans and information Vol 2, Pt 2, Ch 1, 2.2.2 (*See* Note 8)		X
Generator set test results that state the engine maximum load steps which satisfy the quality of power supply requirements specified in Vol 2, Pt 9, Ch 1, 2.1 Quality of power supplies (QPS)		X
Planned operating profiles for the vessel at sea and during manoeuvring as agreed with the Operators		X
List of sub-contractors for main parts	X	
Operation and service manuals (*See* Note 9)	X	
Risk-based analysis (for engine control system) (*See* Note 10)	X	
Test program resulting from risk-based analysis (for engine control system) (*See* Note 10)	X	
Production specifications for castings and welding procedures	X	
Evidence of quality control system for engine design, production and in-service maintenance (*See* Notes 5 and 11)	X	
Type approval certification for environmental tests of control components (*See* Note 12)	X	
Details of the engine type test program and the type test report (*See* Note 13)		X
Fatigue analysis for all high pressure oil fuel and hydraulic oil piping arrangements (*See* Note 14)		X
Engine test schedule (FAT and shipboard trials, *see* Vol 2, Pt 2, Ch 1, 2.2.1)		X

Documentation verifying compliance with inclination limits (*See* Vol 2, Pt 1, Ch 3, 4.6 Inclination of ship)		X
Combustion pressure-displacement relationship		X
Plans and details for dead ship condition starting arrangements, *see* Vol 2, Pt 7, Ch 3,12.11 Dead ship condition starting arrangements.		X

Note 1. LR Form 2073 will be supplied on application. Note that the turbochargers, if required to be type approved, are to have plans and particulars submitted as detailed in Vol 2, Pt 2, Ch 1, 2.2.4.

Note 2. For approval of materials and weld procedure specifications. The weld procedure specification is to include details of pre- and post-weld heat treatment, weld consumables and fit-up conditions.

Note 3. For each cylinder for which dimensions and details differ.

Note 4. If integral with engine and not integrated in the bedplate.

Note 5. Including identification of components to ensure traceability in accordance with the Rules for Materials.
Note 6. Details of the system so far as supplied by the engine manufacturer such as: main dimensions, operating media and maximum working pressures.

Note 7. The documentation to contain specifications for pressures, pipe dimensions and materials.

Note 8. The System Design Description required by Table 1.2.2 Additional Plans and particulars to be submitted is to include a general overview of the operating principles, supported by schematics explaining the functionality of individual systems and sub-systems. The information is to relate to the engine capability and functionality under defined operating and emergency conditions such as recovery from a failure or malfunction, with particular reference to the functioning of programmable electronic systems and any sub-systems. The information is also to indicate if the engine has different modes of operation, such as to limit exhaust gas emissions and/or to run under an economic fuel consumption mode or any other mode that is electronically controlled.

Note 9. Operational manuals are to contain maintenance requirements (servicing and repair) including details of any special tools and gauges that are to be used with their fitting/settings together with any test requirements on completion of maintenance. They are to include a description of each system's particulars and include reference to the functioning of sub-systems.

Note 10. Where engines rely on hydraulic, pneumatic or electronic control of fuel injection and/or valves, the risk-based analysis is to address the mechanical, pressure containing, electrical, electronic and programmable electronic systems and arrangements that support the operation of the engine. It is to demonstrate that failure of the control system will not result in the operation of the engine being degraded beyond acceptable performance criteria for the engine and that suitable risk mitigation has been achieved in accordance with Vol 2, Pt 2, Ch 1, 4.2 Information to be submitted. The risk-based analysis will not be explicitly approved by LR.

Note 11. Including quality plan for sourcing, traceability, design, installation and testing of all components used in the fuel and hydraulic oil systems installed with the engine. *See* Vol 2, Pt 2, Ch 1, 8.1.11.

Note 12. Tests are to demonstrate the ability of the control, protection and safety equipment to function as intended under the specified testing conditions as per Lloyd's Register Type Approval Test Specification Number 1.

Note 13. The type test report may be submitted shortly after the conclusion of the type test. For electronically controlled engines evidence of type testing of the engine with the programmable electronic system, or a proposed factory acceptance test plan at the engine builders with the programmable electronic system functioning, is to be submitted to verify the functionality and behaviour under normal operating and fault conditions of the programmable electronic control system. Where required this is to include proposals for short-term, high power operation.

Note 14. Required for engine operation where failure of the pipe or its connection or a component would be the cause of engine unavailability. The analysis is to concentrate on high pressure components and sub-systems and recognise the pressures and fluctuating stresses that the pipe system may be subject to in normal service.

~~15.2.1(h)~~ 2.2.1 Schedule of testing at the engine packager's or system integrator's facility, pre-sea trial commissioning and sea trials is to be submitted. The test schedules are to identify all modes of engine operation and the sea trials are to include typical port manoeuvres under all intended engine operating modes. The schedule is to include:

(a) testing and trials to demonstrate that the engine is capable of operating as described in ~~Vol 2, Pt 2, Ch 1, 15.2 Documentation required for design review~~ Table 1.2.1 Plans and particulars to be submitted, Note 8;
(b) tests to verify that the response of the complete mechanical, hydraulic, electrical and electronic system is as predicted for the intended operational modes; and
(c) testing required to verify the conclusions of the risk-based analysis.

The scope of these tests is to be agreed with LR based on the risk-based analysis.

~~15.2.2~~ 2.2.2 In addition to the applicable plans and particulars required by Vol 2, Pt 9, Ch 1, 1.4 Documentation required for design review, the following information for control, alarm, monitoring and safety systems relating to the operation of an electronically controlled engine is to be submitted:

(a) Engine configuration details, *see* Vol 2, Pt 2, Ch 1, ~~15.5 Control engineering systems~~ 15.3.2.
    (i) Local and remote means to carry out system configuration.
    (ii) Engine builder procedures for undertaking configuring.
    (iii) Roles and responsibilities for configuration (e.g. Engine builder, engine packager, system integrator or other nominated party) with accompanying schedule.

   (iv) Configurable settings and parameters (including those not to be modified from a default value).
   (v) Configuration for propulsion, auxiliary or emergency engine application.

Configuration records are to be maintained and are to be made available to the Surveyor at testing and trials and on request in accordance with Vol 2, Pt 9, Ch 1, 1.7 Alterations and additions and Vol 2, Pt 9, Ch 11, 1.2.3.

(b) Software quality plans, including configuration management documents.
(c) Software safety evidence.
(d) Software assessment inspection report such as SCA or IEC 61508, as applicable.

2.2.3 For emergency engines, evidence and details showing compliance with Vol 2, Pt 2, Ch 1, 13.5 Emergency engines.

2.2.4 For turbochargers, the following plans and particulars are to be submitted for information:

(a) Cross-sectional drawing with principal dimensions and materials of housing components for containment evaluation.
(b) Drawings of the housing and rotating parts including details of blade fixing.
(c) Material specifications (chemical composition and mechanical properties) of all parts mentioned in (b) above including details of the material and quality control system to be used for these parts.
(d) Welding details and welding procedure of above mentioned parts, if applicable.
(e) Documentation of containment in the event of disc fracture, *see* Vol 2, Pt 2, Ch 1, 11.5 Containment.
(f) Type test reports.
(g) Operational data and limitations, i.e.:

- Maximum permissible operating speed (rpm)
- Alarm level for over-speed
- Maximum permissible exhaust gas temperature before turbine
- Alarm level for exhaust gas temperature before turbine
- Minimum lubrication oil inlet pressure
- Lubrication oil inlet pressure low alarm set point
- Maximum lubrication oil outlet temperature
- Lubrication oil outlet temperature high alarm set point
- Maximum permissible vibration levels, i.e. self- and externally generated vibration
  (Alarm levels may be equal to permissible limits but are not to be reached when operating the engine at 110 per cent power or at any approved intermittent overload beyond 110 per cent.)

(h) Arrangement of lubrication system, all variants within a range.
(i) A list of main current suppliers and subcontractors for rotating parts and an operation and maintenance manual.
(j) Documentation* of safe torque transmission when the disc is connected to the shaft by an interference fit, *see* Vol 2, Pt 2, Ch 1, 11.6 Disk-shaft shrinkage fit.
(k) Information on expected lifespan, considering creep, low cycle fatigue and high cycle fatigue.
(l) Operation and maintenance manuals*.
    Note * Applicable to two sizes in a generic range of turbochargers.

2.2.5 The following information is to be submitted to LR for acceptance of oil mist detection equipment and alarm arrangements:

(a) Description of oil mist detection equipment and system including alarms.
(b) Copy of the test house report in accordance with the requirements of Test Specification No. 4. *See also* Vol 2, Pt 2, Ch 1, 12.4 Crankcase oil mist detection system.
(c) Schematic layout of engine oil mist detection arrangements showing location of detectors/sensors and piping arrangements and dimensions.
(d) Maintenance and test manual which is to include the following information:
    (i) Intended use of equipment and its operation;
    (ii) Functionality tests to demonstrate that the equipment is operational and that any faults can be identified and corrective actions notified;
    (iii) Maintenance routines and spare parts recommendations;
    (iv) Limit setting and instructions for safe limit levels; and
    (v) Where necessary, details of configurations in which the equipment is and is not to be used.

~~2.1.7~~ 2.2.6 Where considered necessary ~~additional documentation may be required~~ Lloyd’s Register (hereinafter referred to as ’LR’) may require additional documentation to be submitted.

2.3 Additional submission requirements

2.3.1 In addition to the requirements of Vol 2, Pt 2, Ch 1, 2.2 Submission requirements and Table 1.2.1 Plans and particulars to be submitted, the plans and information in Vol, Pt 2, Ch 1, 2.3.2 and Table 1.2.2 Additional Plans and particulars to be submitted are to be submitted.

~~2.1.4~~ 2.3.2 Risk Assessment (RA) as required by Vol 2, Pt 1, Ch 3 Requirements for Design, Construction, Installation and Sea Trials of Engineering Systems is to be submitted. The RA is to be carried out in accordance with the requirements of Vol 2, Pt 1, Ch 3, 17 Risk Assessment (RA) and is to include the following associated sub-systems:

- Starting and stopping.
- Fuel oil.
- Lubricating oil.
- Cooling water (fresh and sea).
- Air induction.
- Exhaust.
- Engine mounting.
- Control and monitoring.
- Electrical power supplies.
- Hydraulic oil (for valve lift).

It is not necessary to consider failure modes relating to the engine components.

Table 1.2.2: Additional Plans and particulars to be submitted

Document	For information	For appraisal
	(X *indicates reason for submission)*	
Control engineering aspects in accordance with Vol 2, Pt 9 Electrotechnical Systems.		X
Details of the securing and collision arrangements (*see also* Vol 2, Pt 1, Ch 3, 3.3.5 and Vol 2, Pt 1, Ch 3, 5.3 Machinery fastenings to 5.6 Resin chocks).		X
Arrangement of interior lighting, where provided.		X
Calculations and information for short-term high power operation where applicable.	X	
Power/speed operational envelope.	X	
Where it is proposed to use alloy castings, micro alloyed or alloy steel forgings or iron castings: Details of the chemical composition, heat treatment and mechanical properties.		X
System Operational Concept covering the Propulsion system, *see* Vol 2, Pt 1, Ch 3, 3.4 System operational concept.		X
System Design Description for engine systems, *see* Vol 2, Pt 1, Ch 3, 3 Documentation required for design review.		X

■ Section 3
Materials and components

~~3.2~~ 3.1 Crankshaft materials

Existing paragraph 3.2.1 *has been renumbered* 3.1.1.

Existing Table 1.3.1 Material testing requirements *has been deleted.*

Table 1.3.1: Test and certification requirements for engine components

Part	Materials Tests				Component Tests		LR Component Certification
	Material Properties *see* Note 1	Surface Inspection *see* Note 2	Ultrasonic Inspection	LR Material Certification *see* Note 3	Hydraulic testing *see* Note 5	Visual inspection	
					(All Engines)		
Steel castings for welded bedplates	All	All	All	a	-	fit-up + post-welding	X
Steel forgings for welded bedplates	All	-	-	a	-	fit-up + post-welding	X
Plates for welded bedplates, frames and entablatures	All	-	-	a *see* Note 4	-	fit-up + post-welding	X
Bearing transverse girders	All	All	All	a	-	V	X
Crankcases, welded or cast	All	-	-	a *see* Note 4	-	V	X
Welded frame box	All	All	All	b *see* Note 4	-	fit-up + post-welding	X

Engine block	>400kW/ cylinder	-	-	a	1,5p	V	X
Cylinder block	All	-	-	a	1,5p	V	X
Welded cylinder frames	All	All	All	a *see* Note 4	-	fit-up + post-welding	X
Tie rod	All	Bore>400mm *see* Note 6	-	b	-		-
Bolts and studs for cylinder covers, crossheads, main bearings, tie rods and connecting rod bearings	Bore>300mm	Bore>400mm	Bore>400mm	c	-	V	-
Cylinder liner	Bore>300mm	-	-	a	7,0 bar	-	X
Cylinder cover	Bore>300mm	Bore>400mm	All *see* Note 17	a	7,0 bar *see* Note 7	V	X
Turbocharger, shaft and rotor	Bore>300mm	-	-	c	-	V	X
Turbocharger casing	*See* Note 11	*See* Note 11	*See* Note 11	c	G *see* Note 8	V	X
Crankshaft	All	All	All	a	-	V+D	X
Crankshaft coupling flange (non-integral)	Main propulsion bore>400mm	-	-	a	-	V+D	X
Semi-built crankshaft (Crankthrow, forged main journal and journals with flange)	All	All	All	a		V+D	X
Connecting rod assembly	All	All	Bore>400mm	a	-	V+D	X
Crankshaft coupling bolts	Bore>400mm	Bore>400mm	Bore>400mm	c	-	V+D	X
Crosshead	Bore>400mm	Bore>400mm	Bore>400mm	a	-	V	X
Piston rod, if applicable	Bore>400mm	Bore>400mm	Bore>400mm	a	-	V	X
Piston crown (steel)	Bore>400mm	Bore>400mm	All	a	7,0 bar *see* Note 7	V	X
Steel gear wheels for camshaft drives	Bore>400mm	Bore>400mm	-	b	-	-	-
High pressure fuel injection system - valve, pipe, pump body (pressure side) (10)	All	-	-	a	Lesser of 1,5p or p+300 bar *see* Note 9	V	X
Coolers, both sides (12)	-	-	-	-	G	V	*See* Note 13
Accumulator of common rail fuel or servo oil system	Accumulators with a capacity>0,5 l	-	-	-	1,5p		X
Bearings for main, crosshead, and crankpin (14)	>800kW/cylinder	-	>800kW/cylinder	c	-	V+D	-
Piping, pumps, actuators, etc., for hydraulic systems, if applicable	All	-	All (Welds)	*See* Note 15	1,5p	V	*See* Note 13
Engine driven pumps - oil, water, fuel, bilge	-	-	-	*See* Note 15	G	-	X
Cylinder jacket cooling space (16)	-	-	-	-	G	-	-
Exhaust pipe cooling space	-	-	-	-	G	-	-

<table>
<tr><td>Exhaust valve cooling space</td><td>-</td><td>-</td><td>-</td><td>-</td><td>G</td><td>-</td><td>-</td></tr>
<tr><td>Air compressor inc. cylinders, liners, covers, intercoolers & after coolers (12)</td><td>Calculated crankpin≥50mm</td><td>-</td><td>-</td><td>c</td><td>Air side: 1,5p
Water side: G</td><td>-</td><td>X</td></tr>
<tr><td colspan="8">SYMBOLS</td></tr>
<tr><td colspan="2">Bore dimensions refer to engine cylinder bores
p = Max. working pressure of item concerned</td><td colspan="3">G = Pressure test at greater of 4,0 bar or 1,5p
V = Visual examination of accessible surfaces by Surveyor (11)</td><td colspan="3">D = Dimensional inspection, including surface condition
X = LR Component Certification required</td></tr>
<tr><td colspan="8">Note 1. Material properties include chemical composition and mechanical properties, and also surface treatment such as surface hardening (hardness, depth and extent), peening and rolling (extent and applied force). All required material tests are to be carried out in accordance with the relevant Chapters of the Rules for Materials.
Note 2. Magnetic particle testing is to be carried out on ferromagnetic materials, liquid penetrant testing is only to be carried out on non-ferritic materials. Visual examination alone is not considered sufficient.
Note 3. The certificate type required refers to the Rules for Materials, Ch 1, 3.1.3.
Note 4. Where welding is carried out, welding procedures and welder qualifications are to be carried out in accordance with the Rules for Materials, Chapter 12 Welding Qualifications.
Note 5. Hydraulic testing is applied on the water/oil side of the component. The full lengths of cooling spaces are to be tested where applicable. Tests are to be witnessed by the Surveyor and an LR Test Certificate will be issued.
Note 6. Magnetic particle testing of tie rods may be confined to the threaded portions and the adjacent material over a length equal to that of the thread.
Note 7. For forged steel cylinder covers and piston crowns alternative testing methods may be specially considered. Where the piston rod seals the piston crown cooling space, it is to be tested after assembly.
Note 8. Hydraulic testing of the cooling space. Turbocharger air coolers need only be tested on the water side.
Note 9. Where components are subjected to an autofrettage process approved by LR, the component pressure test may be omitted. The assembled system containing such components is to be shown, where practicable, to be pressure-tight as required for hydraulic systems.
Note 10. Pumps used in jerk or times pump systems need only have the assembled high pressure containing components hydraulically tested.
Note 11. Dependent upon specific application.
Note 12. Material and component certification for accumulators or coolers which are classed as pressure vessels are dependent on the operating pressure and temperature, *see* Vol 2, Pt 8, Ch 2, 1.5 Classification of fusion welded pressure vessels and 1.7 Materials.
Note 13. LR component certification required where the component is necessary for the operation of main propulsion or auxiliary engines which are the source of power for services essential for safety or for the operation of the ship at sea.
Note 14. Ultrasonic testing required to prove full contact between basic material and bearing metal; only chemical properties required for materials testing.
Note 15. Material certification requirements for pumps and piping components are dependent on the operating pressure and temperature, *see* Vol 2, Pt 7, Ch 1, 2.3 Classes of piping system and components and Vol 2, Pt 7, Ch 1, 4 Materials.
Note 16. Where it is more practical to test the assembled engine (i.e. for engines with a multiple cylinder engine block), a leak test at working pressure may be accepted.
Note 17. Cylinder covers and liners manufactured from spheroidal or nodular graphite iron castings may not be suitable for ultrasonic NDE, depending upon the grain size and geometry. An alternative NDE procedure is to be agreed with LR.</td></tr>
</table>

~~3.1~~ 3.2 Materials test and inspections

~~3.1.1~~ 3.2.1 ~~Components~~ Materials and components for engines are to be manufactured, tested and certified as indicated in Table 1.3.1 ~~Material testing requirements~~ Test and certification requirements for engine components and in accordance with the relevant requirements of ~~*Rules for the Manufacture, Testing and Certification of Materials* (hereinafter referred to as~~ the Rules for Materials.

3.2.2 For components of novel design special consideration will be given to the acceptability of material properties and non-destructive testing requirements. For components and materials not specified in Table 1.2.1 Plans and particulars to be submitted, consideration will be given by LR upon submission and review of their full details.

3.2.3 With reference to Table 1.3.1 Test and certification requirements for engine components, certification is to be in accordance with Rules for Materials, Ch 1, 3.1 General and with the type as specified in Table 1.3.1 Test and certification requirements for engine components.

3.2.4 The certificate is to be in accordance with the Rules for Materials, Ch 1, 3.1.3(d) where the manufacturer or material supplier operates an approved LR Quality Scheme.

3.2.5 The manufacturer is not exempted from responsibility for any relevant tests and inspections of those parts for which documentation is not explicitly requested by LR.

Existing sub-Section 6.3 *from* Vol 2, Pt 1, Ch 3 *has been renumbered* 3.3 *in* Vol 2, Pt 2, Ch 1.

~~6.3~~ 3.3 Hydraulic ~~testing~~ tests

~~6.3.1~~ 3.3.1 ~~Items~~ In general, items are to be tested by hydraulic pressure as indicated in ~~Table 3.6.1 Test pressures~~ Table 1.3.1 Test and certification requirements for engine components. Where design features are such that modifications to the test requirements shown in Table 1.3.1 Test and certification requirements for engine components are necessary, alternative proposals for hydraulic tests are to be submitted for special consideration.

~~6.3.2~~ 3.3.2 Where a manufacturer has demonstrated to LR that they have an acceptable quality management system, a manufacturer's hydraulic test certificate may be accepted for engine driven pumps as detailed in ~~Table 3.6.1 Test pressures~~ Table 1.3.1 Test and certification requirements for engine components. Recognition and acceptance of the works quality control processes can be by one of the following routes:
(a) Approval under the LR ~~Quality Scheme for Machinery~~ Quality Assurance Scheme for Machinery (QAM).
(b) Approval of an alternative quality scheme recognized by LR.
(c) Approval by LR through auditing of the manufacturer's quality system.

Existing Table 3.6.1 Test Pressures *from* Vol 2, Pt 1, Ch 3 *has been deleted.*

3.4 Alignment gauges

3.4.1 All main and auxiliary oil engines exceeding 220 kW are to be provided with an alignment gauge which may be either a bridge weardown gauge, or a micro-meter clock gauge for use between the crankwebs. Only one micrometer clock gauge need be supplied for each ship provided the gauge is suitable for use on all engines.

Existing sub-Section 6.5 *from* Vol 2, Pt 1, Ch 3 *has been renumbered* 3.3 *in* Vol 2, Pt 2, Ch 1.

~~6.5~~ 3.5 Autofrettage

Existing paragraph 6.5.1 *has been renumbered* 3.5.1*.*

~~6.5.2~~ 3.5.2 LR certificates are to be issued for components subject to autofrettage, provided the attending Surveyors are satisfied that the required process parameters and associated QA processes have been applied.

■ *Section 4*
Crankshaft design

4.1 ~~Application and information to be submitted~~ Scope

4.1.5 The requirements of Section 4 apply to engines of powers greater that 110kW intended for Mobility or Ship Type systems.

4.2 Information to be submitted

Existing paragraph 4.1.5 *has been renumbered* 4.2.1.

Existing sub-Sections 4.2 *to* 4.11 *have been renumbered* 4.3 *to* 4.12.

■ *Section 5*
Construction and welded structures

5.4 Post-weld heat treatment

Existing paragraph 5.3.7 *has been renumbered* 5.4.3*.*

■ *Section 6*
Safety arrangements on engines

6.1 ~~Cylinder relief~~ Relief valves

~~6.2 Crankcase relief valves~~

Existing paragraphs 6.2.1 *to* 6.2.2 *have been renumbered* 6.1.2 *to* 6.1.3.

~~6.2.3~~ 6.1.4 Each valve is to be fitted with a flame arrester that permits flow for crankcase pressure relief and prevents the passage of flame following a crankcase explosion. The valves are to be type tested in a configuration that represents the installation arrangements that will be used on an engine and in accordance with Vol 2, Pt 2, Ch 1, ~~13 Type testing procedure for crankcase explosion relief valves~~ 12 Type Testing – General. The valves are to be positioned on engines to minimise the possibility of danger and damage arising from emission of the crankcase atmosphere. Where shielding from the emissions is fitted to a valve, the valve is to be tested to demonstrate that the shielding does not adversely affect the operational effectiveness of the valve.

Existing paragraph 6.2.13 *has been renumbered* 6.1.5*.*

~~6.2.14~~ 6.1.6 A copy of the installation and maintenance manual required by Vol 2, Pt 2, Ch 1, ~~6.2 Crankcase relief valves~~ 6.1.5 is to be provided on board ship.

Existing paragraphs 6.2.15 *and* 6.2.16 *have been renumbered* 6.1.7 *and* 6.1.8*.*

6.2 Number of relief valves

Existing paragraphs 6.2.4 *to* 6.2.8 *have been renumbered* 6.2.1 *to* 6.2.5.

6.3 Size of relief valves

Existing paragraphs 6.2.9 *to* 6.2.12 *have been renumbered* 6.3.1 *to* 6.3.4*.*

~~6.3~~ 6.4 Vent pipes

~~6.3.1~~ 6.4.1 ~~Ventilation~~ Through ventilation of crankcase, and any arrangement which could produce a flow of external air within the crankcase, is in principle not permitted except for dual fuel engines where crankcase ventilation is to be provided. Where crankcase vent pipes are fitted, they are to be made as small as practicable to minimise the inrush of air after an explosion. Vents from crankcases of main engines are to be led to a safe position on deck or other approved position.

Existing paragraphs 6.3.2 *and* 6.3.3 *have been renumbered* 6.4.2 *and* 6.4.3.

Existing sub-Sections 6.4 *and* 6.5 *have been renumbered sub-Sections* 6.5 *and* 6.6.

6.7 Fire extinguishing system for scavenge manifolds

6.7.1 Crosshead type engine scavenge spaces in open connection with cylinders are to be provided with approved fixed or portable fire extinguishing arrangements which are to be independent of the fire extinguishing system of the engine room.

~~6.7~~ 6.8 Oil mist detection

~~6.7.1~~ 6.8.1 Where crankcase oil mist detection/monitoring arrangements are fitted, they are to be of a type approved by LR, tested in accordance with Vol 2, Pt 2, Ch 1, ~~13 Type testing procedure for crankcase explosion relief valves~~ 12 Type Testing – General and comply with Vol 2, Pt 2, Ch 1, ~~6.7 Oil mist detection~~ 6.8.2 to 6.8.15.

Existing paragraph 6.7.2 *has been renumbered* 6.8.2*.*

~~6.7.3~~ 6.8.3 A copy of the oil mist detection equipment maintenance and test manual required by Vol 2, Pt 2, Ch 1, ~~6.7 Oil mist detection~~ 6.8.2 is to be provided on board ship.

Existing paragraphs 6.7.4 *to* 6.7.7 *have been renumbered* 6.8.4 *to* 6.8.7*.*

~~6.7.8~~ 6.8.8 The oil mist detection arrangements are to provide an alarm indication in the event of a foreseeable functional failure in the equipment and installation arrangements. *See* Vol, 2, Pt 9, Ch 1, 2.4.5.

Existing paragraphs 6.7.9 *to* 6.7.15 *have been renumbered* 6.8.9 *to* 6.8.15.

~~6.6~~ 6.9 Emergency operation

~~6.6.1~~ 6.9.1 ~~Diesel engines~~ Engines and their service systems are to be capable of operation for a period of not less than eight hours when the engine compartment is flooded by sea-water to a mean level corresponding to the height of the lowest part of the engines' crankshaft main bearing journals with the ship in the most limiting trim.

■ *Section 7*
Starting arrangements

7.2 Electrical starting arrangements

7.2.1 Where main engines are fitted with electric starters, two batteries are to be fitted. Each battery is to be capable of starting the engines when cold and the combined capacity is to be sufficient without recharging to provide the number of starts of the main engines as required by Vol 2, Pt 7, Ch 3, 12 Air compressors and air starting arrangements. In other respects batteries are to comply with the requirements of Vol 2, Pt 9, Ch 2, 7 Batteries.

■ *Section 8*
Piping ~~systems~~

8.1 ~~General~~ Oil fuel, hydraulic and high-pressure oil systems

8.1.1 ~~Diesel engine piping systems are, in general,~~ Oil fuel and hydraulic oil piping systems are to comply with ~~the requirements of~~ Vol 2, Pt 7, Ch 1 Piping Design Requirements and Vol 2, Pt 2, Ch 3 Steam Turbines~~, due regard being paid to the particular type of installation~~ as applicable.

8.1.2 Engine fuel system components are to be designed to accommodate the maximum peak pressures experienced in service. Where fuel injection pumps are fitted, this applies in particular to the fuel injection pump supply and spill line piping which may be subject to high-pressure pulses from the pump. Connections on such piping systems should be chosen to minimise the risk of pressurised oil fuel leaks.

Existing paragraph 15.4.2 *has been renumbered* 8.1.3.

~~8.2.3~~ 8.1.4 All external high pressure fuel delivery ~~lines~~ piping between the fuel injection pump or high pressure fuel pumps and the fuel injectors ~~are~~ is to be protected with a jacketed piping system capable of containing ~~fuel~~ leakage and/or spray of flammable fluid from a high pressure line failure. ~~If flexible hoses are used for shielding purposes, these arrangements are to be approved.~~ The jacketed piping arrangements are to be approved, *see* Table 1.2.1 Plans and particulars to be submitted.

~~8.2.4~~ 8.1.5 The protection required by Vol 2, Pt 2, Ch 1, 8.1.4 is to prevent fuel oil or fuel oil mist from reaching a source of ignition on the engine or its surroundings. Suitable drainage arrangements are to be made for draining any fuel oil leakage to one or more collector tank(s) fitted in a safe position and ~~also prevent~~ for preventing contamination of lubricating oil by fuel oil. An alarm is to be provided to indicate that leakage is taking place. The collector tank arrangement is to be approved.

~~15.4.4~~ 8.1.6 The hydraulic oil pressure piping between the high pressure hydraulic pumps and hydraulic actuators is to be protected with a jacketed piping system or suitable enclosure capable of containing hydraulic oil leakage from a high pressure pipe failure. Where flammable oils are used in high-pressure systems to operate exhaust valves, the oil pipe lines between the high-pressure oil pump and actuating oil pistons are to be protected with a jacketed piping system capable of preventing oil spray from a high-pressure line failure.

8.1.7 All lubricating and hydraulic oil pipes and oil fuel pipes that are not jacketed nor suitably enclosed are to be suitably installed and screened to avoid oil spray or leakage onto hot surfaces, *see also* Vol 2, Pt 7, Ch 3, 2.9.4 and Vol 2, Pt 7, Ch 5, 11.10.2 as applicable.

~~15.4.11~~ 8.1.8 Where flammable oils are used in high-pressure actuating systems, a ~~The~~ fatigue analysis is to be carried out in accordance with a suitable standard ~~applicable to the system under consideration~~ and all anticipated pressure, pulsation and vibration loads are to be ~~addressed~~ considered. The analysis is to demonstrate that the design and arrangements are such that the likelihood of failure is as low as reasonably practicable. The analysis is to identify all assumptions made and standards to be applied during manufacture and testing ~~of the system~~. Any potential weak points that may develop due to incorrect construction or assembly are also to be identified.

Existing paragraph 15.4.5 *has been renumbered* 8.1.9.

Existing paragraph 8.2.6 *has been renumbered* 8.1.10.

~~15.4.12~~ 8.1.11 For high pressure oil containing and mechanical power transmission systems, the quality plan for sourcing, design, installation and testing of components is to address the following issues (*see* Table 1.2.1, Note 11):

(a) Design and manufacturing standard(s) applied.
(b) Materials used for construction of key components and their sources.
(c) Details of the quality control system applied during manufacture and testing.
(d) Details of type approval, type testing or approved type status assigned to the machinery or equipment.
~~(d)~~(e) Details of installation and testing recommendations for the machinery or equipment.

Existing paragraph 8.2.2 *has been renumbered* 8.1.12.

Existing paragraph 8.1.2 *has been renumbered* 8.1.13.

~~8.6~~ 8.2 Intake and exhaust systems

8.2.1 Where the surface temperature of the exhaust pipes and silencer may exceed 220°C, they are to be water cooled or efficiently lagged to minimise the risk of fire and to prevent damage by heat. Where lagging covering the exhaust piping system including flanges is oil-absorbing or may permit penetration of oil, the lagging is to be encased in sheet metal or equivalent. In locations where the Surveyor is satisfied that oil impingement could not occur, the lagging need not be encased.

Existing paragraph 8.6.3 *has been renumbered* 8.2.2.

8.2.3 Where the exhausts of two or more engines are led to a common silencer or exhaust gas-heated boiler or economiser, an isolating device is to be provided in each exhaust pipe.

8.2.4 For alternatively fired furnaces of boilers using exhaust gases and oil fuel, the exhaust gas inlet pipe is to be provided with an isolating device and interlocking arrangements whereby oil fuel can only be supplied to the burners when the isolating device is closed to the boiler.

8.2.5 In two-stroke main engines fitted with exhaust gas turbochargers which operate on the impulse system, provision is to be made to prevent broken piston rings entering the turbine casing and causing damage to blades and nozzle rings.

Existing paragraphs 8.6.1 *and* 8.6.2 *have been renumbered* 8.2.6 *and* 8.2.7.

Existing paragraphs 8.6.4 *to* 8.6.11 *have been renumbered* 8.2.8 *to* 8.2.15.

Existing sub-Section 12.13 *from* Vol 2, Pt 7, Ch 3 *has been renumbered* 8.3 *in* Vol 2, Pt 2, Ch 1.

~~12.13~~ 8.3 Starting air pipe systems and safety fittings

Existing paragraphs 12.13.1 *to* 12.13.8 *from* Vol 2, Pt 7, Ch 3 *have been renumbered* 8.3.1 *to* 8.3.8 *in* Vol 2, Pt, 2, Ch 1.

~~8.2 Fuel oil systems~~

~~8.2.1 Fuel oil arrangements are to comply with the requirements ofVol 2, Pt 7, Ch 3, 3 Fuel oil burning arrangements and Vol 2, Pt 7, Ch 3, 4 Fuel oil pumps, pipes, fittings, tanks, etc. as applicable.~~

~~8.2.5 Diesel engine fuel system components are to be designed to accommodate the maximum peak pressures experienced in service. In particular, this applies to the fuel injection pump supply and spill line piping which may be subject to high-pressure pulses from the pump. Connections on such piping systems should be chosen to minimise the risk of pressurised fuel oil leaks.~~

~~8.2.7 The arrangements of injection pumps, injectors and connections are to be such that leak-off fuel and lubricating oil cannot cross-contaminate each other.~~

Existing sub-Section 8.3 *has been renumbered* 8.4.

~~8.4~~ 8.5 Lubricating oil systems

~~8.4.1 Lubricating oil arrangements are to comply with the requirements of Vol 2, Pt 7 Piping Systems as applicable.~~

~~8.4.2 Where the lubricating oil for main propelling engines is circulated under pressure, provision is to be made for the efficient filtration of the oil. The filters are to be capable of being cleaned without stopping the engine or reducing the supply of filtered oil to the engine. Proposals for an automatic by-pass for emergency purposes in high speed engines are to be submitted for special consideration.~~

Existing paragraphs 8.4.3 *to* 8.4.7 *have been renumbered* 8.5.1 *to* 8.5.5.

~~8.5 Engine cooling water systems~~

~~8.5.1 Cooling water arrangements are to comply with the requirements of Vol 2, Pt 7 Piping Systems, as applicable.~~

~~8.7 High pressure oil systems~~

~~8.7.1 Where flammable oils are used in high pressure systems, the oil pipe lines between the high pressure oil pump and actuating oil pistons are to be protected with a jacketed piping system capable of preventing oil spray from a high-pressure line failure.~~

Existing sub-Section 8.8 *has been renumbered* 8.6.

~~8.8~~ 8.6 Air induction systems

(*Part only shown*)

~~8.8.1~~ 8.6.1 An air filter is to be fitted at the inlet to each engine. The air filters are to satisfy the following:

(e) For engines drawing air from the engine compartment, be as close as possible to the engine air inlet and in such cases, the debris screen required by Vol 2, Pt 2, Ch 1, ~~8.8 Air induction systems~~ 8.6.4(c) may be omitted.

~~8.8.2~~ 8.6.2 Where there is a requirement to provide a ducted air system to convey air from inlets on deck to the engine, the requirements of Vol 2, Pt 2, Ch 1, ~~8.8 Air induction systems~~ 8.6.3 to Vol 2, Pt 2, Ch 1, ~~8.8 Air induction systems~~ 8.6.6 are to be complied with.

Existing paragraphs 8.8.3 *to* 8.8.6 *have been renumbered* 8.6.3 *to* 8.6.6.

■ *Section 9*
Control and monitoring of main, auxiliary and emergency engines

9.1 General

(*Part only shown*)

9.1.2 Oil mist detection, engine bearing temperature monitors or alternative methods for crankcase protection are to be provided:

(b) For engines of 2,250 kW and above or having cylinders of more than 300 mm bore.
Note 1. For ~~medium and high speed~~ trunk piston engines automatic shutdown of the engine is to occur.
Note 2. For ~~slow speed~~ crosshead engines, automatic slow-down is to occur.

9.1.3 All main and auxiliary engines intended for ~~essential services~~ Mobility or Ship Type systems are to be provided with means of indicating the lubricating oil pressure supply to them. Where such engines are of more than ~~220~~ 37 kW, audible and visual alarms are to be fitted to give warning of an appreciable reduction in pressure of the lubricating oil supply. Further, these alarms are to be actuated from the outlet side of any restrictions, such as filters, coolers, etc.

9.2 ~~Propulsion~~ Main engine ~~speed~~ governors

9.2.1 An efficient speed governor is to be fitted to each ~~diesel~~ main engine ~~that provides mechanical drive to propeller(s) and~~ so adjusted ~~so~~ that the speed does not exceed that for which the engine is ~~approved~~ to be certified by more than 15 per cent.

9.2.2 ~~Diesel engines~~ Engines coupled to electrical generators that are the source of power for main electric propulsion are to comply with the requirements for electrical generator engines in respect of governors and overspeed protection devices.

9.3 ~~Electrical generator and auxiliary~~ Auxiliary engine ~~speed~~ governors

9.3.1 ~~Diesel~~ Auxiliary engines intended for driving electrical generators are to be fitted with governors which, with fixed setting, are to control the speed ~~within the design limits of the electrical system requirements~~. Unless otherwise required by the electrical system power supply requirements, the governor is to control the engine speed within 10 per cent momentary variation and five per cent permanent variation~~. Except where permitted in accordance with Vol 2, Pt 2, Ch 1, 9.3 Electrical generator and auxiliary engine speed governors, this is to be achieved~~ when the full load is suddenly taken off ~~and~~ or, when after running on no load for at least 15 minutes, the load is suddenly applied as follows:

(a) For engines with BMEP less than 8 bar, full load, or

(b) For engines with BMEP greater than 8 bar, 800/BMEP per cent, but not less than one-third, of full load, the full load being attained in not more than two additional equal stages as rapidly as possible.

9.3.2 ~~In order to design the load management of the main and emergency electrical power systems in accordance with Vol 2, Pt 9, Ch 4, 4.9 Load management, where diesel engines are of a type that cannot meet the requirements of Vol 2, Pt 2, Ch 1, 9.3 Electrical generator and auxiliary engine speed governors and Vol 2, Pt 2, Ch 1, 9.3 Electrical generator and auxiliary engine speed governors, load step trials are to be carried out. The trials are to demonstrate the load steps that are required to increase the mechanical load on the engine from no load to full load and full load rejection, whilst keeping the momentary variations in engine speed of within 10 per cent and permanent variations in engine speed within five per cent. The results of the trials are to be submitted to LR for consideration.~~ If an engine cannot achieve the requirements of Vol 2, Pt 2, Ch 1, 9.3.1 then the actual load step is to be declared and verified through testing to ensure the requirements specified in Vol 2, Pt 9, Ch 1, 2.1 Quality of power supplies (QPS)are satisfied.

9.3.4 For alternating current installations, the permanent speed variations of the machines intended for parallel operation are to be equal within a tolerance of ±0.5 per cent. Momentary speed variations with load changes in accordance with Vol 2, Pt 2, Ch 1, 9.3 Electrical generator and auxiliary engine speed governors are to return to and remain within one per cent of the final steady state speed. Where there are no stated electrical power supply requirements for a particular installation, this should normally be accomplished within five but in no case more than eight seconds. For quality of power supplies, *see* Vol 2, Pt 9, Ch 1, 2.1 Quality of power supplies (QPS).

9.4 Overspeed protective devices

9.4.1 Each main engine developing 220 kW or over which can be declutched or which drives a controllable ~~(reversible)~~ pitch propeller and also each auxiliary engine developing 220 kW and over for driving an electric generator, is to be fitted with an approved overspeed protective device.

9.6 Unattended machinery

9.6.1 Where ~~machinery is~~ main and auxiliary engines are fitted with automatic or remote controls so that under normal operating conditions ~~it does not~~ they do not require any manual intervention by the operators, ~~it is~~ they are to be provided with the alarms and safety arrangements required by Vol 2, Pt 2, Ch 1, 9.1 General as appropriate. Alternative arrangements which provide equivalent safeguards will be considered.

9.6.2 Where machinery is arranged to start automatically or from a remote control station, interlocks are to be provided to prevent start-up under conditions which could present a hazard to the machinery.

Existing paragraph 9.6.4 *has been renumbered* 9.6.3.

Existing paragraph 9.6.2 *has been renumbered* 9.6.4.

Existing paragraph 9.6.3 *has been renumbered* 9.6.5.

9.7 ~~Diesel engines~~ Engines for propulsion purposes

9.7.1 Alarms and safeguards are indicated in Vol 2, Pt 2, Ch 1, ~~9.7 Diesel engines for propulsion purposes~~ 9.7.2 to 9.7.8 and Table 1.9.1 Engines for propulsion purposes: Alarms and slow-downs and Table 1.9.2 Engines for propulsion purposes: Automatic shutdowns. *See also* Vol 2, Pt 2, Ch 1, 9.1 General and Vol 2, Pt 2, Ch 1, 9.6 Unattended machinery.

(*Part only shown*)
Table 1.9.1 ~~Diesel engines~~ Engines for propulsion purposes: Alarms and slow-downs

Item	Alarm	Note
Oil mist concentration in crankcase or bearing temperature	High	~~Automatic slow-down of slow speed engines, *see* Vol 2, Pt 2, Ch 1, 9.6 Unattended machinery~~ Automatic slow-down of crosshead engines, *see* Vol 2, Pt 2, Ch 1, 7.1.2. For trunk piston engines, *see* Table 1.9.2 Engines for propulsion purposes: Automatic shutdowns
Cylinder lubricator flow	Low	One sensor per lubricator unit on crosshead engines. Slow-down ~~(automatic on medium and high speed engines)~~
Cylinder coolant inlet pressure or flow*	Low	Slow-down (automatic on ~~medium and high speed~~ trunk piston engines)
Cylinder coolant outlet temperature*	1st stage high	Per cylinder (if a separate system) Slow-down (automatic on ~~medium and high speed~~ trunk piston engines)
Fuel oil temperature or viscosity*	High and Low	Heavy oil only
Fuel oil high pressure piping*	Leakage	*See* Vol 2, Pt 2, Ch 1, ~~9.6 Unattended machinery~~ 9.6.5
Charge air cooler outlet temperature	High and Low	~~4-stroke medium and high speed~~ Trunk piston engines
Exhaust gas temperature*	High	Per cylinder. Slow-down (automatic on ~~medium and high speed~~ trunk piston engines), *see* Note 5
Turbocharger exhaust gas inlet temperature	High	Each turbocharger, *see* Note 9
Turbocharger lubricating oil inlet pressure	Low	~~If system not integral with turbocharger~~ *See* Note 10
Turbocharger lubricating oil outlet temperature	High	Each bearing, if system not integral with turbocharger. *See* Notes ~~6~~8 and 10
Direction of rotation	Wrong way	Reversible engines, *see also* Vol 2, Pt 2, Ch 1, ~~9.7 Diesel engines for propulsion purposes~~ 9.7.7
Automatic start of engine	Failure	*See* Vol 2, Pt 2, Ch 1, ~~9.7 Diesel engines for propulsion purposes~~ 9.7.7

Note 1. Where 'per cylinder' appears in this Table, suitable alarms may be situated on manifold outlets for ~~medium and high speed~~ trunk piston engines.

Note 5. For trunk piston engine powers <500 kW/cylinder, but total power >500 kW, a common sensor for exhaust gas manifold temperature ~~is to~~ may be fitted.

Note 9. Alarm and indication of the exhaust gas temperature at turbocharger inlet may be waived if alarm and indication for individual exhaust gas temperature is provided for each cylinder and the alarm level is set to a value specified by the turbocharger manufacturer.

Note 10. Separate sensors are to be provided if the lubrication oil system of the turbocharger is not integrated with the lubrication oil system of the engine or if it is separated by a throttle or pressure reduction valve from the engine lubrication oil system. Where the turbocharger is provided with a self-contained lubricating oil system integrated with the turbocharger, lubricating oil inlet pressure need not be monitored.

Table 1.9.2 ~~Diesel engines~~ Engines for propulsion purposes: ~~Alarms and~~ Automatic shutdowns

Item	Alarm	Note
Lubricant oil inlet pressure	2nd stage low	Automatic shutdown of engines, *see* Vol 2, Pt 2, Ch 1, 9.6 Unattended machinery
Oil mist concentration in crankcase or bearing temperature	High	Automatic shutdown of ~~medium and high speed~~ trunk piston engines, *see* Vol 2, Pt 2, Ch 1, ~~9.6 Unattended machinery~~ 7.1.2
Cylinder coolant outlet temperature	2nd stage high	Automatic shutdown of ~~medium and high speed~~ trunk piston engines, *see* Vol 2, Pt 2, Ch 1, 9.6 Unattended machinery
Overspeed	High	Automatic shutdown of engine, *see also* Vol 2, Pt 2, Ch 1, 9.4 Overspeed protective devices. Details of alternative proposals in accordance with the manufacturer’s instructions may be submitted for consideration

9.7.5 ~~Where the fuel oil supply is heated,~~ The oil fuel supply may be fitted with an automatic control for viscosity ~~may be fitted in lieu~~ instead of the temperature control required by Vol 2, Pt 2, Ch 1, 9.7 Diesel engines for propulsion purposes.

(*Part only shown*)
Table 1.9.3: Auxiliary ~~diesel~~ engines: Alarms and shutdowns

Item	Alarm	Note
Feed water or water/thermal fluid forced circulation flow (if fitted)	Low	*See* Vol 2, Pt 7, Ch 3, 6.2 Feed and circulation pumps and Note 2
Turbocharger lubricating oil outlet temperature	High	Each bearing, *see* Note 5
Turbocharger lubrication oil inlet pressure	Low	*See* Note 6
Uptake temperature	High	To monitor for soot fires. *See* Notes 2 and 3

Note 4. For emergency engines, including engines used for the emergency source of electrical power required by SOLAS, *see* Vol 2, Pt 7, Ch 3, 12 Air compressors and air starting arrangements.

Note 5. Unless provided with a self-contained lubricating oil system integrated with the turbocharger.

Note 6. Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design, alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer’s instructions may be accepted as an alternative.

~~■ *Section 10*~~

~~Alarms and safeguards for emergency diesel engines~~

~~10.1 General~~

9.9 Alarms and safeguards for emergency engines

~~10.1.1~~ 9.9.1 These requirements apply to emergency ~~diesel~~ engines required to be immediately available in an emergency and capable of being controlled remotely or automatically.

~~10.1.2~~ 9.9.2 Alarms and safeguards are indicated in Table ~~1.10.1 Alarms and safeguards for emergency diesel engines~~ 1.9.4. *See also* Vol 2, Pt 2, Ch 1, 9.1 General and Vol 2, Pt 2, Ch 1, ~~9.6 Unattended machinery~~ 9.6.5.

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Existing paragraphs 10.1.3 *to* 10.1.6 *have been renumbered* 9.9.3 *to* 9.9.6.

~~10.1.7~~ 9.9.7 Local indications of at least those items listed in Table ~~1.10.1~~ 1.9.4 Alarms and safeguards for emergency ~~diesel~~ engines are to be provided within the same space as the ~~diesel~~ engines and are to remain operational in the event of failure of the alarm and safety systems.

(*Part only shown*)

Table ~~1.10.1~~ 1.9.4 Alarms and safeguards for emergency diesel engines

Item	**Alarm**	**Alarm**	**Note**
Emergency ~~Diesel~~ Engine	≥ 220 kW	<220 kW	-
Fuel oil leakage from pressure pipes	Leakage	Leakage	*See* Vol 2, Pt 2, Ch 1, ~~9.6 Unattended machinery~~ 9.6.5

■ *Section 10*

Factory Acceptance Test and Shipboard Trials of Internal Combustion Engines

10.1 Safety

10.1.1 Before any test run is carried out, all relevant equipment for the safety of attending personnel is to be made available by the manufacturer/ shipyard and is to be operational. This is to include crankcase explosive conditions protection, overspeed protection and any other shutdown function.

10.1.2 The overspeed protective device is to be set to a value which is not higher than the overspeed value that was demonstrated during the type test for that engine. This set point is to be verified by the Surveyor.

10.2 General

10.2.1 Engines which are to be subjected to trials on the test bed at the manufacturer's works and under attendance by the Surveyor(s) are to be tested in accordance with the scope of works trials specified in Vol 2, Pt 2, Ch 1, 10.3 Works trials (factory acceptance test). The scope of the trials is to be agreed between the LR Surveyor and the manufacturer prior to testing. At the discretion of the Surveyor, the scope of the trials may be extended depending on the engine application.

10.2.2 Where multiple engines of the same design are manufactured, a quality assurance approach to approval may be applied if the manufacturer meets the requirements of and is registered on the Quality Assurance Scheme for Machinery (QAM), *see* Vol 2, Pt 2, Ch 1, 6 Safety arrangements on engines.

10.2.3 Before any official testing the engines are to be run in as prescribed by the engine manufacturer.

10.2.4 Adequate test bed facilities for loads as required in Table 1.10.1 Scope of works trials for engines are to be provided. All fluids used for testing purposes such as fuel, lubrication oil and cooling water are to be suitable for the purpose intended, e.g. they are to be clean and if necessary, pre-heated to achieve the recommended operating temperature. This applies to all fluids used temporarily or repeatedly for testing purposes only.

10.2.5 Survey of the engine is to include:

(a) Jacketing of high-pressure fuel oil lines including the system used for the detection of leakage.

(b) Screening of pipe connections in piping containing flammable liquids.

(c) Insulation of hot surfaces by taking random temperature readings that are to be compared with corresponding readings obtained during the type test. This is to be done while running at the maximum approved rating for the actual application. Use of contact thermometers may be accepted at the discretion of the attending Surveyor. If the insulation is modified subsequently to the Type Approval Test, LR may request more enhanced temperature measurements as required by the LR's Type Approval Test Specification No. 4, Chapter 2, 1.3.10 (Fire Protection Measures).

These surveys are normally to be made during the works trials by the manufacturer and the attending Surveyor, but at the discretion of LR parts of these surveys may be postponed to the shipboard testing.

10.2.6 Where the type test was not carried out on the complete engine, as described in Vol 2, Pt 2, Ch 1, 1.1.5, integration tests are to be conducted as part of the works or shipboard trials to confirm satisfactory operation of the complete engine. This includes satisfactory functioning on all fuel types on which the engine is to operate. *See also* Vol 2, Pt 2, Ch 1, 10.4.7.

10.3 Works trials (factory acceptance test)

10.3.1 The purpose of the works trials is to verify design parameters such as power, adherence to approved limits (e.g. maximum pressure) and functionality, and to establish reference values or base lines for later reference in the operational phase.

10.3.2 For each load point the parameters to be recorded include: Power and speed; Fuel index (or equivalent reading); Maximum combustion pressures; Exhaust gas temperature before turbine and from each cylinder (or from manifold, *see* Note 5 in Table 1.9.1 Engines for propulsion purposes: Alarms and slow-downs); Charge air temperature and pressure.

10.3.3 For all stages of the works trials the pertaining operation values are to be measured and recorded by the engine manufacturer. All results are to be compiled in an acceptance protocol to be issued by the engine manufacturer. Where the engine designer requires through life monitoring of crankshaft deflections, such measurements are also to be taken before and after works acceptance trials in accordance with the engine designer’s requirements.

10.3.4 In each case given in Table 1.10.1 Scope of works trials for engines, all measurements conducted at the various load points are to be carried out at steady operating conditions. The readings for MCR, i.e. 100 per cent power (rated maximum continuous power at corresponding rpm) are to be taken twice at an interval of at least 30 minutes. For all load points provision should be made for time needed by the Surveyor to carry out visual inspections.

10.3.5 Calibration records for the instrumentation are to be presented to the attending Surveyor upon request.

Table 1.10.1: Scope of works trials for engines

Main engines driving propellers and waterjets		
Trial condition	Duration	Note
100% power (rated power) at rated engine speed, R	≥ 60 minutes	After having reached steady conditions
110% power at engine speed corresponding to 1,032*R	30–45 minutes	After having reached steady conditions (*see* Note 1)
90% (or maximum continuous power), 75%, 50% and 25%	—	Powers in accordance with the nominal propeller curve
Starting and reversing manoeuvres	—	—
Testing of governor and independent overspeed protective device	—	*See* Vol 2, Pt 2, Ch 1, 7.2 Electrical starting arrangements
Shutdown device	—	*See* Vol 2, Pt 2, Ch 1, 7.4 Engine control, alarm, monitoring and safety system power supplies
Engines driving generators		
Trial condition	Duration	Note
100% power (rated power) at rated engine speed, R	≥ 50 minutes	After having reached steady conditions (*see* Note 2)
110% power	30 minutes	After having reached steady conditions (*see* Notes 2 and 3)
75%, 50% and 25% power and idle run	—	(*see* Note 2)
Start-up tests	—	—
Testing of governor and independent overspeed protective device	—	*See* Vol 2, Pt 2, Ch 1, 7.3 Starting of the emergency source of power
Shutdown device	—	*See* Vol 2, Pt 2, Ch 1, 7.4 Engine control, alarm, monitoring and safety system power supplies
Note 1. After running on the test bed, the fuel delivery system of main engines is normally to be so adjusted that overload power cannot be given in service. Note 2. The test is to be performed at rated speed with a constant governor setting. Note 3. After running on the test bed, the fuel delivery system of engines driving generators must be adjusted such that overload (110%) power can be given in service after installation on board, so that the governing characteristics including the activation of generator protective devices can be fulfilled at all times.		

10.3.6 Alternatives to the detailed tests may be agreed between the manufacturer and LR when the overall scope of tests is found to be equivalent. The scope of the trials may be expanded depending on the engine application, service experience, or other relevant reasons.

10.3.7 For electronically controlled engines:
(a) integration tests in accordance with Vol 2, Pt 2, Ch 1, 2.2.1; and
(b) verification of engine configuration, *see* Vol 2, Pt 2, Ch 1, 13.3.2, and that the approved software quality plans, including the software configuration management process, are to be applied.

10.3.8 Checks of components to be presented for inspection after the works trials are left to the discretion of the Surveyor.

10.3.9 The Surveyor may require that after the trials the fuel delivery system is restricted so as to limit the engines to run at not more than 100 per cent power. The setting of the restriction is to be made as applicable to the intended fuel. Any restriction settings, and other changes to the engine's fuel injection equipment required for operation on special fuels, are to be recorded and included by the engine manufacturer.

10.3.10 For the duration of the acceptance test, no interventions or adjustments will be made to the machinery under test.

10.3.11 The testing of exhaust gas emissions is to comply with MARPOL as applicable.

10.4 Shipboard trials

10.4.1 The purpose of the shipboard testing is to verify compatibility with power transmission and driven machinery in the system, safety, control and auxiliary systems necessary for the engine and integration of engine/ shipboard control systems, as well as other items that had not been dealt with in the FAT (Factory Acceptance Testing).

10.4.2 After installation on board, engines are to undergo shipboard trials as specified in Table 1.10.2. The scope of the trials may be expanded depending on the engine application, service experience or other relevant reasons, and is to be agreed between the LR Surveyor and the Shipyard prior to testing.

Table 1.10.2: Scope of shipboard trials for engines

Main engines driving fixed-pitch propellers (*see* Notes 1 and 2)		
Trial condition	Duration	Note
At rated engine speed, R	≥ 4 hours	–
At engine speed corresponding to normal continuous power	≥ 2 hours	–
At engine speed corresponding to 1,032*R	30 minutes	Where the engine adjustment permits, *see* Vol 2, Pt 2, Ch 1, 11.1.7
At minimum on-load speed	–	–
Starting and reversing manoeuvres	–	*See* Vol 2, Pt 2, Ch 1, 7 Starting arrangements and Vol 2, Pt 7, Ch 3, 12 Air compressors Air compressors and air starting arrangements
In reverse direction of propeller rotation during the dock or sea trials at a minimum engine speed of 0,7*R	10 minutes	–
Control, monitoring, alarms and safety systems	–	Operation to be demonstrated
Where imposed, test to ensure engine can pass safely through barred speed range	–	–
Single engine driving a generator for propulsion only		
Trial condition	Duration	Note
100% power (rated propulsion power), *see* 11.2.3	≥ 4 hours	(*see* Notes 3 and 4)
At normal continuous propulsion power	≥ 2 hours	(*see* Notes 3 and 4)
110% power (rated propulsion power)	30 minutes	–
In reverse direction of propeller rotation at a minimum speed of 70% of the nominal propeller speed	10 minutes	(*see* Notes 3 and 4)
Starting manoeuvres	–	–
Control, monitoring, alarm and safety systems	–	Operation to be demonstrated
Note 1. For main propulsion engines driving controllable pitch propellers, waterjets or reversing gears, the tests for main engines driving fixed-pitch propellers apply as appropriate. Note 2. Controllable pitch propellers are to be tested with various propeller pitches. Note 3. The tests are to be performed at rated speed with a constant governor setting. Note 4. Tests are to be based on the rated electrical powers of the electric propulsion motors.		

10.4.3 Engines driving generators or other auxiliaries for Mobility or Ship Type systems are to be subjected to an operational test for at least 4 hours. During the test, the set concerned is required to operate at its rated power for an extended period. It is to be demonstrated that the engine is capable of supplying 100 per cent of its rated power, and in the case of shipboard generating sets account shall be taken of the times needed to actuate the generator's overload protection system.

10.4.4 Trials are to include demonstration of engine control, monitoring, alarm and safety system operation to confirm that they have been provided, installed and configured as intended and in accordance with the relevant requirements for main, auxiliary or emergency engines except items already verified during the works trials.

10.4.5 For electronically controlled engines:
(a) shipboard tests in accordance with Vol 2, Pt 2, Ch 1, 2.2.1; and
(b) verification of engine configuration, *see* Vol 2, Pt 2, Ch 1, 13.3.2, and that the approved software quality plans, including the software configuration management process, are to be applied.

10.4.6 The suitability of an engine to burn residual or other special fuels is to be demonstrated where the machinery installation is arranged to burn such fuels in service. *See also* Vol 2, Pt 9, Ch 1, 7.2.1.

10.4.7 For both manual and automatic engine control systems, acceleration and deceleration through any barred speed range, is to be demonstrated. The transit times are to be equal or less than the times stated in the approved documentation and are to be recorded. This also applies when passing through the barred speed range in reverse rotational direction, especially during the stopping test. The ship's draft and speed during all these demonstrations are to be recorded. Where a controllable pitch propeller is fitted, the pitch is also to be recorded.

10.4.8 The engine is to be checked for stable running (steady fuel index) at both upper and lower borders of the barred speed range. Steady fuel index means an oscillation range less than five per cent of the effective stroke (idle to full index).

~~■ *Section 11*~~
~~Mass produced engines~~

Existing Section 11 *has been deleted in its entirety.*

■ *Section ~~12~~ 11*
~~Mass produced turbochargers~~ Turbochargers

~~12.1 Application~~

~~12.1.1 The following procedure applies to the inspection and testing of exhaust driven turbo chargers which are manufactured on the basis of mass production methods similar to Vol 2, Pt 2, Ch 1, 11.1 Definition as applicable and for which the maker has requested approval.~~

11.1 General

11.1.1 Turbochargers are to be approved, either separately or as a part of an engine. The requirements are written for exhaust gas driven turbochargers, but apply in principle also for engine driven chargers.

11.1.2 Some requirements are reduced for turbochargers manufactured on the basis of mass production methods. Mass produced turbochargers are defined as those which are produced under the following criteria:
(a) In quantity under strict quality control of material and parts, according to a quality assurance scheme acceptable to LR.
(b) By the use of jigs and automatic machine tools designed to machine parts to specified tolerances for interchangeability, and which are verified on a regular inspection basis.
(c) By assembly with parts taken from stock and requiring little or no fitting.
(d) With bench tests carried out on individual assembled turbochargers according to a specified programme.
(e) With appraisal by final examination of turbochargers selected at random after workshop testing.

11.1.3 Plans and particulars are to be submitted as required by Vol 2, Pt 2, Ch 1, 2.2.4.

11.1.4 Alarms and slowdowns for turbochargers are required as listed in Table 1.9.1 Engines for propulsion purposes: Alarms and slow-downs, Table 1.9.2 Engines for propulsion purposes: Automatic shutdowns and Table 1.9.3 Auxiliary diesel engines: Alarms and shutdowns.

11.1.5 Turbochargers are to be designed for the operating conditions defined in Vol 2, Pt 1, Ch 3, 4 Operating conditions. The component lifetime and the alarm level for speed are to be based on 45°C air inlet temperature.

11.1.6 A Type test, *see* Vol 2, Pt 2, Ch 1, 12.2 Turbochargers, is to be carried out on a standard unit taken from the assembly line and is to be witnessed by the Surveyor.

11.1.7 LR reserves the right to limit the duration of validity of approval of a mass produced turbocharger. LR is to be informed, without delay, of any change in the design of the turbocharger, in the manufacturing or control processes, in the selection of materials or in the list of subcontractors for main parts.

Existing sub-Sections 7.3 *to* 7.5 *from* Vol 2, Pt 1, Ch 3 *have been renumbered sub-Sections* 11.2 *to* 11.4 *in* Vol 2, Pt 2, Ch 1.

~~7.3~~ 11.2 Dynamic balancing

Existing paragraph 7.3.1 *has renumbered* 11.2.1.

~~7.4~~ 11.3 Overspeed tests

~~7.4.1~~ 11.3.1 All fully bladed rotor sections and impeller/inducer wheels are to be overspeed tested for three minutes at either 20 per cent above the maximum permissible speed at room temperature or 10 per cent above the maximum permissible speed at the normal working temperature. The overspeed test may be waived for forged wheels that are individually controlled by an approved non-destructive method; this test will not be waived for wheels of the unit to be type tested.

~~7.5~~ 11.4 Mechanical running tests

Existing paragraph 7.5.1 *has been renumbered* 11.4.1.

~~7.5.1~~ 11.4.2 Upon application, with details of a historical audit covering previous testing of turbochargers manufactured under an approved quality assurance scheme, consideration will be given to confining the test outlined in Vol 2, Pt 2, Ch 1, 11.3.1 to a representative sample of turbochargers.

11.5 Containment

11.5.1 In the event of any rotor burst, the turbocharger casing is to fully contain all debris and no part may penetrate the casing of the turbocharger or escape through the air intake.

11.5.2 Containment is to be demonstrated by testing which is to be fully documented. For approval of a generic range of turbochargers, subject to satisfactory performance, only the largest unit is required to be tested. In any case, it must be demonstrated (e.g. by calculation) that the selected test unit is representative for the whole generic range.

11.5.3 The minimum test speeds for rotor burst testing is to be the same as those required for the overspeed test specified in 11.3.1.

11.5.4 Containment tests are to be performed at working temperature.

11.5.5 Calculations using a simulation model and numerical analysis to demonstrate the required containment may be accepted in lieu of the practical containment test, provided that:
(a) The numerical simulation model has been validated and its suitability/accuracy has been proven by direct comparison between calculation results and the practical containment test for a reference application (reference containment test). This test is to be performed at least once by the manufacturer for acceptance of the numerical simulation method in lieu of tests.
(b) The corresponding numerical simulation for the containment is performed for the same speeds as specified for the containment test.
(c) Material properties for high-speed deformations are to be applied in the numeric simulation. The correlation between normal properties and the properties at the pertinent deformation speed are to be substantiated.
(d) The design of the turbocharger regarding geometry and kinematics is similar to the turbocharger that was used for the reference containment test. In general, totally new designs will call for a new reference containment test.

11.6 Disk-shaft shrinkage fit

11.6.1 For turbochargers where the disc is connected to the shaft with an interference fit, calculations are to substantiate safe torque transmission during all relevant operating conditions such as maximum speed, maximum torque and maximum temperature gradient combined with minimum shrinkage amount.

Volume 2, Part 2, Chapter 1

Existing sub-Section 12.2 *has been deleted*.

~~12.3~~ 11.7 ~~Continuous inspection of individual units~~ Works testing and inspection

~~12.3.1~~ 11.7.1 LR Surveyors are to be provided with free access to the manufacturer's workshop to inspect at random the quality control measures and to witness the ~~under mentioned~~ tests required by Vol 2, Pt 2, Ch 1, 11.7.3 to 11.7.7 as deemed necessary, ~~as well as~~ and to have free access to all control records and subcontractors' certificates.

~~12.3.2~~ 11.7.2 Each individual unit is to be tested in accordance with Vol 2, Pt 2, Ch 1, ~~12.3 Continuous inspection of individual units~~ 11.7.4 to 11.7.7 ~~by the maker who is to issue a final certificate~~.

~~12.3.3~~ 11.7.3 Rotating parts of the turbocharger blower are to be marked for easy identification with the ~~appropriate certificate~~ corresponding certificate. Component identification is to be in accordance with the Rules for Materials.

~~12.3.4~~ 11.7.4 Material tests of the rotating parts are to be ~~carried out by the maker or his subcontractor~~ in accordance with the requirements of the Rules for Materials as applicable. ~~The relevant certificate is to be produced and filed to the satisfaction of the Surveyor.~~

~~12.3.5~~ 11.7.5 Pressure ~~testing is~~ tests are to be carried out in accordance with ~~Table 3.6.1 Test pressures~~ Table 1.3.1 Test and certification requirements for engine components. ~~In general, the pressure tests are to be carried out as indicated.~~ Special consideration will be given where design or testing features may require modification of the test requirements.

~~12.3.6~~ 11.7.6 Dynamic balancing and overspeed tests ~~is~~ are to be carried out, *see* ~~Vol 2, Pt 1, Ch 3, 7.3 Dynamic balancing and Vol 2, Pt 1, Ch 3, 7.4 Overspeed tests, in accordance with the approved procedure for quality control~~ 11.2 Dynamic balancing and 11.3 Overspeed tests. ~~If each forged wheel is individually controlled by an approved non-destructive examination method no overspeed test may be required except for wheels of type test unit.~~

~~12.3.7~~ 11.7.7 A mechanical running, ~~*see* Vol 2, Pt 1, Ch 3, 7.5 Mechanical running tests~~ is to be carried out, *see* Vol 2, Pt 2, Ch 1, 11.4 Mechanical running tests. The duration of the running test may be reduced to 10 minutes provided that the manufacturer is able to verify the distribution of defects established during the running tests on the basis of a sufficient number of tested ~~turbo-charges~~ turbochargers. For manufacturers who have facilities in their Works for testing the turbochargers on an engine for which the turbochargers are intended, the bench test may be replaced by a test run of 20 minutes at overload (110% of the rated output) on this engine.

Existing sub-Section 12.4 *has been deleted*.

11.8 Certification

11.8.1 The manufacturer is to adhere to a quality system designed to ensure that the designer's specifications are met, and that manufacturing is in accordance with the approved drawings.

11.8.2 Turbochargers are to be delivered with:

(a) For turbochargers manufactured using mass production methods as defined in Vol 2, Pt 2, Ch 1, 11.1.2, a manufacturer's certificate that at a minimum cites the applicable type approval, including production assessment.
(b) For all other turbochargers, an LR certificate that at a minimum cites the applicable type approval and the LR Quality Scheme when applicable.

11.8.3 Where the manufacturer is approved under the LR Quality Assurance for Machinery Scheme (QAM), the audits will include specific focus on:

(a) Chemical composition of material for the rotating parts.
(b) Mechanical properties of the material of a representative specimen for the rotating parts and the casing.
(c) UT and crack detection of rotating parts.
(d) Dimensional inspection of rotating parts.
(e) Rotor dynamic balancing.
(f) Hydraulic testing of cooling spaces in accordance with Table 1.2.1 Plans and particulars to be submitted.
(g) Overspeed test of all compressor disks as per Vol 2, Pt 2, Ch 1, 11.3.1.

■ *Section 12*

Type Testing – General

12.1 Engines

~~1.5.1~~ 12.1.1 New engine types or developments of existing types are to be subjected to an agreed programme of type testing to complement the design appraisal and review of documentation. The programme will need to include short term high power operation where applicable.

12.1.2 Requirements for type testing of engines are contained within the Lloyd’s Register Type Approval System, Test Specification No. 4 – *Type Testing of Reciprocating Internal Combustion Engines and Associated Ancillary Equipment*. In all cases the type test specification is to be agreed with LR.

12.1.3 Type testing specifications for other auxiliary systems are to be submitted for approval if they are to be tested separately from the engine.

12.1.4 Wherever practical, type tests are to be conducted with the engine control systems operational in the approved configuration, *see* Vol 2, Pt 2, Ch 1, 2.1 Approval process and Vol 2, Pt 2, Ch 1, 13.3.2. Configuration management documents that satisfy the requirements of ISO 10007 or an equivalent national or international standard, are to be reviewed at testing for validity and referenced in the type test report.

12.1.5 In addition to type testing against the requirements of Test Specification No. 4, engines may also be submitted for approval against recognised International or National Standards. Where this additional testing and appraisal is carried out satisfactorily, it will be stated on the Type Approval Certificate.

12.2 Turbochargers

12.2.1 Requirements for type testing of turbochargers are contained within the Lloyd’s Register Type Approval System, *Test Specification No. 4 – Type Testing of Reciprocating Internal Combustion Engines and Associated Ancillary Equipment*. In all cases the type test specification is to be agreed with LR.

12.3 Crankcase explosion relief valves

12.3.1 Requirements for type testing of crankcase explosion relief valves are contained within the Lloyd’s Register Type Approval System, *Type Testing of Test Specification No. 4 – Reciprocating Internal Combustion Engines and Associated Ancillary Equipment*. In all cases the type test specification is to be agreed with LR.

12.3.2 The test specification is only applicable to explosion relief valves fitted with flame arresters. Where internal oil wetting of a flame arrester is a design feature of an explosion relief valve, alternative testing arrangements that demonstrate compliance with these requirements may be proposed by the manufacturer. The alternative testing arrangements are to be submitted to LR for appraisal.

12.4 Crankcase oil mist detection system

12.4.1 Requirements for type testing of crankcase oil mist detection systems are contained within the Lloyd’s Register Type Approval System, *Type Testing of Test Specification No. 4 – Reciprocating Internal Combustion Engines and Associated Ancillary Equipment*. In all cases the type test specification is to be agreed with LR.

12.4.2 This test specification is also applicable to oil mist detection systems intended for gear cases.

12.4.3 Acceptance of crankcase oil mist detection equipment is at the discretion of LR based on the appraisal of plans and particulars and the test house report of the results of type testing. *See* Vol 2, Pt 2, Ch 1, 2.2.6.

~~■ *Section 13*~~

~~Type testing procedure for crankcase explosion relief valves~~

Existing Section 13 *has been deleted in its entirety.*

~~■ *Section 14*~~

~~Type testing procedure for crankcase oil mist detection and alarm equipment~~

Existing Section 14 *has been deleted in its entirety.*

■ *Section ~~15~~ 13*

Electronically controlled engines

~~15.1~~ 13.1 Scope

Existing paragraph 15.1.1 *has been renumbered* 13.1.1.

13.1.2 These engines may be of the crosshead or trunk-piston type. They generally have no direct camshaft driven fuel systems, but have common rail fuel/hydraulic arrangements and may have hydraulic actuating systems for the functioning of the exhaust systems.

Existing paragraphs 15.1.2 *to* 15.1.4 *have been renumbered* 13.1.3 *to* 13.1.5.

~~15.1.5~~ 13.1.6 During the life of the engine details of any proposed changes ~~that~~ to control, alarm, monitoring or safety systems which may affect ~~the~~ safety and the reliable operation of the engine are to be submitted to LR for approval in accordance with Vol 2, Part 9, Ch 1, 1.1.7.

Existing sub-Section 15.2 *has been deleted.*

Existing sub-Section 15.3 *has been renumbered* 13.2.

Existing sub-Section 15.4 *has been deleted.*

~~15.5~~ 13.3 Control engineering systems

~~15.5.1~~ 13.3.1 Control, alarm, monitoring, safety and programmable electronic systems are to comply with Vol 2, Pt 9~~, Ch 7 Control, Alerts and Safety Systems,~~ Electrotechnical System and Pt 10 Human Factors, as applicable.

~~15.5.2~~ 13.3.2 The engine control, alarm, monitoring and safety systems are to be configured to comply with the relevant requirements (e.g. operating profile, alarms, shutdowns, etc.) of this Chapter and Vol 2, Pt 9~~, Ch 7 Control, Alerts and Safety Systems~~ Electrotechnical System and Pt 10 Human Factors for an engine for main, auxiliary or emergency power purposes. Details of the engine configuration are to be submitted for consideration ~~identifying:~~, *see* Vol 2, Pt 2, Ch 1, 2.2.2(a).
~~(a) Local and remote means to carry out system configuration.~~
~~(b) Engine packager or system integrator procedures for undertaking configuring.~~
~~(c) Roles and responsibilities for configuration (e.g. Engine builder, engine packager, system integrator or other nominated party) with accompanying schedule.~~
~~(d) Configurable settings and parameters (including those not to be modified from a default value).~~
~~(e) Configuration for propulsion, auxiliary or emergency engine application.~~
~~Configuration records are to be maintained and are to be made available to the Surveyor at testing and trials and on request, in accordance with Vol 2, Pt 9, Ch 1, 1.7 Alterations and additions and Vol 2, Pt 9, Ch 1, 6.1 General.~~

~~15.6~~ 13.4 Software

~~15.6.1~~ 13.4.1 Software lifecycle activities are to be carried out in accordance with an acceptable quality management system, *see* Vol 2, Pt 9, Ch 8, 5~~.4 Additional requirements for Mobility category and safety critical systems, Vol 2, Pt 9, Ch 8, 5.4 Additional requirements for Mobility category and safety critical systems and Vol 2, Pt 9, Ch 8, 5.5 Additional requirements for integrated systems~~ Programmable electronic systems (PES).

Existing paragraph 15.6.2 *has been renumbered* 13.4.2.

~~15.6.3~~ 13.4.3 To demonstrate compliance with Vol 2, Pt 2, Ch 1, ~~15.6 Software~~ 15.4.1 and Vol 2, Pt 2, Ch 1, ~~15.6 Software~~ 15.4.2:

(a) software quality plans and safety evidence are to be submitted for consideration, *see* Vol 2, Pt 2, Ch 1, ~~15.2 Documentation required for design review and Vol 2, Pt 2, Ch 1, 15.2 Documentation required for design review~~ 2.2.2(b) and (c); and

(b) an assessment inspection of the engine packager’s or system integrator’s completed development is to be carried out by LR. The inspection is to be tailored to verify application of the standards and codes used in software safety assurance accepted by LR.

Existing sub-Section 15.7 *has been renumbered* 13.5.

Volume 2, Part 2, Chapter 2

Gas Turbines

Effective date 1 January 2016

■ Scope

The requirements of this Chapter are applicable to the design and construction philosophy for gas turbine packages for main propulsion and, where powers exceed 110 kW~~ (150 shp)~~, to those for ~~essential auxiliary~~ services being provided by Mobility systems or Ship Type systems.

■ *Section 1*
General requirements

1.1 Definitions

1.1.1 For the purposes of this Chapter, a gas turbine package is part of a larger system (e.g. the propulsion system) providing power for main propulsion, manoeuvring and/or ~~essential support purposes~~ other Mobility systems and Ship Type systems and is considered to be a series of elements, including all equipment and associated sub-systems necessary to provide specified functions within the intended context of use in the system.

(*Part only shown*)
1.1.4 ~~Essential~~ Mobility and/or Ship Type support services/ship interfaces include:

■ *Section 3*
Performance requirements

3.1 Performance requirements

3.1.3 ~~Essential services~~ Systems supplying the gas turbine package shall be continuously available or recoverable without compromising the safety of the gas turbine system following a single operational action or system/equipment fault.

3.1.4 Where the gas turbine package is required for the provision of ~~essential services~~ Mobility systems or Ship Type systems, the availability of these ~~essential services~~ systems is to be maintained by means of:

- reliability, especially of any single points of failure and taking into account factors such as erosion, fatigue, corrosion and mechanical damage due to vibration; and/or
- redundancy to minimise single points of failure, this is to be supported by the engineering safety and justification report required by Vol 2, Pt 2, Ch 2, 5.2 Documentation.

3.1.7 The gas turbine package is to be capable of continuous operation at its maximum rating in the conditions defined in Vol 2, Pt 1, Ch 3, 4 Operating conditions or the ship's ConOps, whichever is the more onerous. Partial reductions in capability for operation in defined extreme conditions are subject to special consideration and the agreement of the Owner; ~~providing that essential services~~ provided Mobility systems and Ship Type systems are maintained at a declared performance level acceptable to LR and the Owner.

■ *Section 5*
Documentation required for design review

5.2 Documentation

5.2.2 A System Design Description, *see* Vol 2, Pt 1, Ch 3, 3.5 System design description, for the gas turbine package, including references to the System Operational Concept document required by Vol 2, Pt 2, Ch 2, 5.2 Documentation and to Plans required by Vol 2, Pt 2, Ch 2, 5.2 Documentation, is to be submitted so that the function of all ~~essential~~ Mobility, Ship Type and safety critical components and systems necessary for the turbine operation is clearly defined. This is to include a general overview of the operating principles supported by schematics explaining the functionality of individual systems and sub-systems. The information is to relate to the gas turbine capability and functionality under defined normal and reasonably foreseeable abnormal operating and fault conditions such as recovery from a failure, degraded modes of operation, or malfunction, with particular reference to the functioning of the control, monitoring, alert and safety systems and any subsystems.

Volume 2, Part 2, Chapter 2

■ *Section 7*
Design and construction

7.8 Emergency operation

7.8.1 Where a gas turbine is required for the provision of ~~essential services~~ Mobility systems or Ship Type systems, it and its supporting service systems are to be capable of operation when the compartment is flooded to the level of the underside of the lowest exposed portion of the gas turbine casing.

■ *Section 9*
Starting arrangements

9.1 General

9.1.2 Where a gas turbine is required for the provision of ~~essential services~~ Mobility systems or Ship Type systems, equipment for initial starting of the gas turbine is to be provided and arranged such that the necessary initial charge of starting air, hydraulic or electrical power can be developed on board the ship without external aid.

Volume 2, Part 2, Chapter 3

Steam Turbines

Effective date 1 January 2016

■ *Section 1*
General requirements

1.1 Application

1.1.2 The requirements of this Chapter are applicable to steam turbines for main propulsion and ~~essential auxiliary services~~ other Mobility and/or Ship Type systems.

1.4 Inclination of ship

1.4.1 Main and ~~essential~~ auxiliary steam turbines for Mobility and/or Ship Type systems are to operate satisfactorily under the conditions as shown in Table 3.4.2 Inclinations in Pt 1, Ch 3.

Volume 2, Part 3, Chapter 1

Gearing

Effective date 1 January 2016

■ *Section 9*
Control and monitoring

9.1 General

9.1.2 All main and auxiliary gear units, intended for ~~essential services~~ Mobility and/or Ship Type systems, are to be provided with means of indicating the lubricating oil supply pressure. Audible and visual alarms are to be fitted to give warning of an appreciable reduction in pressure of the lubricating oil supply. These alarms are to be actuated from the outlet side of any restrictions, such as filters, coolers, etc.

Volume 2, Part 3, Chapter 2

Shafting Systems

Effective date 1 January 2016

■ *Section 4* Design and construction

4.16 Sternbushes and sterntube arrangements

4.16.10 ~~Two temperature sensors or other approved arrangements that can, where practicable, be replaced without dry-docking or divers are to be provided to ascertain the sterntube aft end bearing temperature.~~ Means for ascertaining the temperature of the sternbush bearings are to be provided, e.g. monitoring of the temperature of the oil in the sterntube.

■ *Section 5* Control and monitoring

5.2 Screwshaft Condition Monitoring (SCM)

5.2.1 For vessels where the notation SCM (Screwshaft Condition Monitoring) is requested, the requirements in either Vol 2, Pt 3, Ch 2, 5.2.2 or 5.2.3 are to be satisfied.

5.2.2 Oil lubricated bearings:

(a) Arrangements are to be provided to allow analysis of the lubricating oil. Oil samples are to be taken under service conditions and are to be representative of the oil within the sterntube, sampling arrangements are to meet the requirements of Vol 2, Pt 7, Ch 3, 8.13.6.

(b) Bearing temperature sensor arrangement is to be designed with either:
  (i) sufficient redundancy in the event of failure of one sensing element and/or its associated cabling; or
  (ii) means to allow replacement of a damaged sensor without requiring dry-docking or divers.

(c) Facilities are to be provided for measurement of bearing weardown.

(d) Approved oil glands that are capable of being replaced without removal of the propeller or withdrawal of the screwshaft are to be fitted.

5.2.3 Water lubricated bearings:

(a) An approved means of monitoring and recording variations in the flow rate of lubricating water using two independent sensors is to be provided.

(b) An approved means of monitoring and recording variations in the shaft power transmission is to be provided.

(c) The maximum permitted weardown of the sternbush is to be indicated by the manufacturer. The maximum weardown allowance is to include both the absolute maximum permitted weardown and the weardown at which it is recommended to carry out an inspection and maintenance. An approved means of monitoring bearing weardown is to be provided. An alignment analysis considering both the newly installed clearance and the proposed absolute maximum allowable weardown, demonstrating that the system will operate satisfactorily within these two limits, is to be submitted and approved.

(d) For open loop systems the manufacturer is to submit information regarding the required standard of lubricating water filtration and lubricating water filters or separators are to be fitted which are able to achieve this requirement. The lubricating water supply is to be fitted with either continuous water sediment measuring equipment, turbidity monitoring equipment or an LR approved extractive sampling and testing procedure.

(e) Where a closed cycle water system is used, arrangements are to allow analysis of the water for at least the following parameters:
  (i) Chloride content
  (ii) Bearing material and metal particles content.

Water samples are to be representative of the water circulating within the sterntube.

(f) The shaft is to either be constructed of corrosion-resistant material or protected with a corrosion-resistant protective liner or coating approved by LR. Where a protective liner or coating is used, this is to meet the requirements of Vol 2, Pt 3, Ch 2, 4.14 Corrosion resistant liners on shafts and a means of assessing the condition of this liner is to be submitted and approved.

(g) Glands are to be capable of being replaced without withdrawal of the screwshaft.

(h) There is to be a shaft starting/clutch engagement block to inhibit starting the shaft until lubricating water flow has been established. This is to only act as a starting block; for lubricating water flow alarm, *see* Table 2.5.3 Alarm and safeguard for water lubricated bearings.

(i) Alternative arrangements are subject to special consideration.

Volume 2, Part 3 Chapter 2

Table 2.5.3: Alarm and safeguard for water lubricated bearings

Item	Alarm	Note
Lubricating water flow	Low	*See* 5.2.3(h)

Volume 2, Part 4, Chapter 2

Water Jet Systems

Effective date 1 January 2016

■ *Section 2*

General requirements

2.1 Water jet arrangement

2.1.1 In general, for a ship to be assigned an unrestricted service notation, a minimum of two water jet systems is to be provided where these form the sole means of propulsion. For ships where a single water jet system is the sole means of propulsion or steering, a detailed engineering and safety justification is to be evaluated by LR, *see* Vol 2, Pt 4, Ch 2, 2.3 Calculations and information. This evaluation process will include a Risk Assessment (RA) in accordance with Vol 2, Pt 1, Ch 3, 17 Risk Assessment (RA), to verify that sufficient levels of redundancy and monitoring are incorporated in the water jet unit’s ~~essential~~ support systems and operating equipment.

Volume 2, Part 4, Chapter 4

Podded Propulsion Units

Effective date 1 January 2016

■ *Section 2*

General requirements

2.1 Pod arrangement

2.1.1 In general, for a ship to be assigned an unrestricted service notation, a minimum of two podded propulsion units is to be provided where these form the sole means of propulsion. For vessels where a single podded propulsion unit is the sole means of propulsion, an evaluation of a detailed engineering justification will be conducted by LR, *see* Vol 2, Pt 4, Ch 4, 2.2 Documentation required for design review. This evaluation process will include the appraisal of a Risk Assessment (RA) to verify that sufficient levels of redundancy and monitoring are incorporated in the podded propulsion unit’s ~~essential~~ support systems and operating equipment.

2.2 Documentation required for design review

2.2.2 Where an engineering justification report is required, the following supporting information is to be submitted:

- A Risk Assessment (RA) in accordance with Vol 2, Pt 1, Ch 3, 17 Risk Assessment (RA) is to be carried out, *see* Vol 2, Pt 4, Ch 4, 2.1 Pod arrangement. The RA is to identify components where failure could cause loss of all propulsion, steering capability or other ~~essential services~~ Mobility systems or Ship Type systems, and the proposed arrangements for preventing and mitigating the effects of such a failure.
- Design standards and assumptions.
- Limiting operating parameters.
- A statement and evidence in respect of the anticipated reliability of any components.

Volume 2, Part 5, Chapter 1

Torsional Vibration

Effective date 1 January 2016

■ *Section 1*
General requirements

1.1 Application

1.1.3 The requirements of this Chapter are applicable to the following systems:

(a) Main propulsion systems formed by oil engines, turbines or electric motors, directly driven or geared to the shafting.

(b) Machinery driven at constant speed by oil engines, developing 110 kW and over, for ~~essential auxiliary services~~ other Mobility and/or Ship Type systems including generator sets which are the source of power for main electric propulsion motors.

■ *Section 3*
Design

3.5 Other machinery components

3.5.2 **Flexible couplings:**

(a) Flexible couplings included in an installation are to be capable of transmitting the mean and vibratory loads without exceeding the makers' recommended limits for angular amplitude or heat dissipation.

(b) Where calculations indicate that the limits recommended by the manufacturer may be exceeded under misfiring conditions, a suitable means is to be provided for detecting and indicating misfiring. Under these circumstances, power and/or speed restriction may be required. Where machinery is ~~non-essential~~ not directly related to Mobility and/or Ship Type, disconnection of the branch containing the coupling would be an acceptable action in the event of misfiring.

Volume 2, Part 5, Chapter 4

Shaft Alignment

Effective date 1 January 2016

■ *Section 2*
Documentation required for design review

2.1 Documentation - Shaft alignment calculations

(*Part only shown*)

2.1.1 Shaft alignment calculations are to be submitted to LR for approval for the following shafting systems:

(b) All geared installations with multiple input/single output, regardless of shaft diameter;

Existing 2.1.1(b) *to* (d) *have been renumbered* 2.1.1(c) *to* (e).

Volume 2, Part 6, Chapter 1

Steering Gear

Effective date 1 January 2016

■ *Section 5*
Design and construction

5.3 Components

5.3.1 Special consideration is to be given to the suitability of any ~~essential~~ component necessary for the operation of the steering gear which is not duplicated. Any such ~~essential~~ component shall, where appropriate, utilise anti-friction bearings such as ball bearings, roller bearings or sleeve bearings which shall be permanently lubricated or provided with lubrication fittings.

Volume 2, Part 7, Chapter 1

Piping Design Requirements

Effective date 1 January 2016

■ *Section 2*
General

2.2 Definitions

(*Part only shown*)
2.2.1 **~~Essential~~ Mobility and/or Ship Type piping systems** are those systems installed for the propulsion and safety of the ship ~~within the Mobility category and Ship Type category~~ (*see* Vol 2, Pt 1, Ch 1, 3 Engineering system designation) and include the following:

2.2.2 **~~Non-essential~~ Ancillary piping systems** are those systems installed for conditions of habitability and recreation~~,~~; ~~are within the Ancillary category and~~ they include the following:
Heating systems.
Air conditioning systems.
Domestic sanitary and fresh water systems.

■ *Section 3*
Assessment

3.1 Design and construction

3.1.2 Materials sensitive to heat, such as aluminium and plastics, are not to be used in ~~essential~~ Mobility systems or Ship Type systems necessary for the safe operation of the ship, or for containing flammable liquids or sea water where leakage or failure could result in fire or in flooding of a watertight compartment.

3.1.3 The strength and construction of pipes, components and fittings is to preclude loss of ~~essential services~~ Mobility and/or Ship Type systems, escape of flammable liquid and flooding.

■ *Section 5*
Pipe connections

5.10 Mechanical connections for piping

(*Part only shown*)
Table1.5.3 Application of mechanical joints

Systems	Kind of connections		
	Pipe unions	Compression couplings (6)	Slip-on joints
Fresh water			
Cooling water system	+	+	+1
Chilled water systems	+	+	+1
Condensate return	+	+	+1
Made water and demineralised water system	+	+	+
~~Non-essential system~~ Ancillary system	+	+	+
Note 3. Approved fire resistant types. Fire resistant type is a type of connection which, when installed in the system and in the event of failure caused by fire, the failure would not result in fire spread, flooding or the loss of ~~an essential service~~ a Mobility or Ship Type system.			

5.10.7 Mechanical pipe connections having sealing components sensitive to heat are not to be used in spaces where leakage or failure caused by fire could result in fire spread, flooding or loss of ~~an essential service~~ a Mobility or Ship Type system.

(*Part only shown*)
5.10.13 Mechanical joints are to be tested in accordance with the test requirements in LR Test Specification Number 2~~, which~~. The programme of testing is to be agreed with LR and is to include the following tests as relevant to the service conditions and the intended application:

■ *Section 9*
Stainless steel piping and components

9.1 General

Table 1.9.1 Minimum thickness for stainless steel pipes

Standard pipe sizes, (outside diameter), in mm			Min. nominal thickness in mm
8,0	to	10,0	0,8
10,2	to	17,2	1,0
21,3	to	48,3	1,6
60,3	to	88,9	2,0
114,3	to	168,3	2,3
219,1			2,6
273,0			2,9
323,9	to	406,4	3,6
over	406,4		4,0
Note Diameters and thicknesses according to national or international standards may be accepted.			

Volume 2, Part 7, Chapter 1

■ *Section 11*
Pipe connections

11.4 Fire performance criteria

(*Part only shown*)
Table 1.11.3 Fire endurance requirements

Piping systems
SEAWATER[1] 11 Cooling water, ~~essential services~~ Mobility and/or Ship Type systems
FRESHWATER 13 Cooling water, ~~essential services~~ Mobility and/or Ship Type systems
MISCELLANEOUS 22 Service air (~~non-essential~~ Ancillary)
NOTES Note 7. For ~~essential services~~ Mobility and/or Ship Type systems, such as fuel oil tank heating and ship's whistle, 'X' is to replace '0'.

11.7 Installation and construction

11.7.5 In the case of pipes intended for ~~essential services~~ Mobility or Ship Type systems each qualified person is, at the place of construction, to make at least one test joint, representative of each type of joint to be used. The joined pipe section is to be tested to an internal hydrostatic pressure of four times the design pressure of the pipe system and the pressure held for not less than one hour, with no leakage or separation of joints. The bonding procedure test is to be witnessed by the Surveyor.

■ *Section 12*
Valves

12.1 Design requirements

12.1.3 Valves having isolation or sealing components sensitive to heat are not to be used in spaces where leakage or failure caused by fire could result in fire spread, flooding or the loss of ~~an essential service~~ a Mobility system or Ship Type system.

Volume 2, Part 7, Chapter 2

Ship Piping System

Effective date 1 January 2016

■ *Section 6*
Drainage units on dewatering service and their connections

6.4 Pump and eductor connections

6.4.2 Pump units required for ~~essential services~~ Mobility systems or Ship Type systems are not to be connected to a common suction or discharge chest or pipe unless the arrangements are such that the working of any units so connected is unaffected by the other units being in operation at the same time.

Volume 2, Part 7, Chapter 2

■ *Section 10* Air, overflow and sounding pipes

10.6 Air pipe closing appliances

10.6.2 Air pipe closing devices are to be ~~of a~~ type ~~acceptable to LR and are to be~~ tested in accordance with the test requirements in LR Test Specification Number 2. The flow characteristics of the closing device are to be determined using water. *See* Vol 2, Pt 7, Ch 2, 10.8 Overflow pipes.

■ *Section 11* Ballast System

11.4 Ballast water treatment system installations

11.4.2 Failure of a ballast water treatment system shall not impair or restrict any other ~~essential~~ Mobility and/or Ship Type piping system, as defined by Ch 1,2.2.1, or any other ~~essential~~ Mobility system or Ship Type system as defined by Vol 2, Pt 1, Ch 1, 3.1 Categories.

Volume 2, Part 7, Chapter 3

Machinery Piping Systems

Effective date 1 January 2016

■ *Section 1* General requirements

1.2 Documentation required for design review

(*Part only shown*)

1.2.1 Three copies of the following plans (in diagrammatic form) and a System Design Description containing the additional information are to be submitted for approval. Additional plans should not be submitted unless the arrangements are of novel or special character affecting classification:

- Arrangements of ~~services~~ Mobility systems or Ship Type systems for power transmission ~~systems which are essential for safety or for the operation of the ship at sea~~.

■ *Section 3* Fuel oil burning arrangements

3.1 Oil burning units

3.1.2 Where steam is required for the main propelling engines, or where steam or thermal fluid is required for auxiliary machinery for ~~essential services~~ Mobility systems or Ship Type systems, or for heating of heavy fuel oil and is generated by burning fuel oil under pressure, there are to be not less than two oil burning units. For auxiliary boilers and thermal oil heaters, a single oil burning unit may be accepted, provided that alternative means, such as an exhaust gas heated boiler or heater, are available for supplying steam or thermal fluid for ~~essential purposes~~ Mobility systems or Ship Type systems. Where the oil burning unit is not of the monobloc type (i.e. separate register and oil supply unit) each oil burning unit is to comprise a pressure pump, suction filter, discharge filter and, when required, a heater.

■ *Section 6* Boiler feed water, condensate and thermal fluid circulation systems

6.1 Feed water piping

6.1.1 Two separate means of feed are to be provided for all main and auxiliary boilers which are required for ~~essential services~~ Mobility or Ship Type systems. In the case of steam/steam generators, one means of feed will be accepted provided steam for ~~essential services~~ Mobility or Ship Type system is available simultaneously from another source.

■ *Section 7*
Engine cooling water systems

7.1 General

7.1.1 Provision is to be made for an adequate supply of cooling water to the main propelling machinery and ~~essential~~ auxiliary engines for other Mobility and/or Ship Type systems, also to the lubricating oil and fresh water coolers and air coolers for electric propelling machinery, where these coolers are fitted. The cooling water pump(s) may be worked from the engines or be driven independently.

7.6 Strainers

7.6.1 Where sea-water is used for the direct cooling of the main engines and ~~essential~~ auxiliary engines for other Mobility and/or Ship Type systems, the cooling water suction pipes are to be provided with strainers which can be cleaned without interruption to the cooling water supply.

■ *Section 8*
Lubricating oil systems

8.5 Alarms

8.5.1 All main and auxiliary engines and turbines intended for ~~essential services~~ Mobility systems or Ship Type systems are to be provided with means of indicating the lubricating oil pressure supply to them. Where such engines and turbines are of more than 37 kW, audible and visual alarms are to be fitted to give warning of an appreciable reduction in pressure of the lubricating oil supply. Further, these alarms are to be actuated from the outlet side of any restrictions, such as filters, coolers, etc.

■ *Section 9*
Control, supervision and monitoring of equipment

9.3 Thermal fluid heaters

(*Part only shown*)
Table 3.9.1: Thermal fluid heaters: Alarms and safeguards

Note 2. For heaters not supplying ~~thermal fluid for services essential for the safety or the operation of the ship at sea~~ Ancillary systems, only the items marked* are required.

■ *Section 12*
Air compressors and air starting arrangements

12.1 General requirements

12.1.1 The requirements of this Section are applicable to reciprocating air compressors intended for starting main engines and auxiliary engines providing essential services and are applicable to both ~~diesel~~ reciprocating internal combustion engines and gas turbine engines.

12.2 Plans and particulars

12.2.1 Detailed plans, particulars, dimensional drawings and material specifications for compressor crankshafts are to be submitted ~~in triplicate~~. Plans and particulars for other parts and calculations, where applicable, are to be submitted to LR upon request.

12.3 Materials

12.3.1 The specified minimum tensile strength of castings and forgings for compressor crankshafts are to be within the limits given in Vol 2, Pt 2, Ch 1, ~~3.2 Crankshaft materials~~ 3.1.1 and for grey cast iron to be not less than 300 N/mm^2.

12.3.3 Materials for components are to be tested as indicated in Vol 2, Pt 2, Ch 1, ~~3.1 Materials test and inspections~~ 3.2 Crankshaft materials.

12.3.4 For compressors with crankshafts with a calculated crank pin diameter equal to or greater than 50 mm, ~~they are to be manufactured and tested in accordance with the requirements of LR's Rules for Materials~~ materials for components are to be tested as indicated in Vol 2, Pt 2, Ch 1, 3.2 Crankshaft materials. For calculated crank pin diameters less than 50 mm, a manufacturer's certificate may be accepted, *see* Ch 1, 3.1 General of the Rules for Materials.

Volume 2, Part 7, Chapter 3

12.5 Testing

12.5.1 ~~Cylinders and liners of air compressors are to be subjected to hydraulic pressure tests at 1,5 times the final pressure of the stage concerned.~~ Air compressors components are to be tested as indicated in Vol 2, Pt 2, Ch 1, Table 1.3.1 Test and certification requirements for engine components.

~~12.5.2 The compressed air chambers of the intercoolers and after coolers of air compressors are to be subjected to hydraulic pressure tests at 1,5 times the final pressure of the stage concerned.~~

12.11 Dead ship condition starting arrangements

Existing 12.13.9 *has been renumbered* 12.11.6.

~~12.13.9~~ 12.11.6 The requirements for battery installations are given in Vol 2, Pt 9, Ch 2 Electrical Power Generator and Energy Storage.

12.13 Starting air pipe systems and safety fittings

Existing sub-Section 12.13 *has been renumbered sub-Section* 8.3 *in* Vol 2, Pt 2, Ch 1.

Existing 12.13.9 *has been renumbered* 12.11.6.

Volume 2, Part 7, Chapter 5

Ship Type Piping Systems

Effective date 1 January 2016

■ *Section 1* General requirements

1.1 General

1.1.2 The requirements in this Chapter cover piping and control systems necessary for ships that have Ship Type piping systems and equipment configured such that, in the event of a single failure or damage in any part of a piping system, the ship will continue to retain availability of ~~essential~~ services relating to the Ship Type.

■ *Section 3* System arrangements

3.1 Piping systems

3.1.1 Piping systems are to be arranged so that supply of ~~essential~~ services relating to the Ship Type will continue to be available in the event of a single failure or damage of a system or item of equipment.

3.1.4 The arrangement of equipment and systems is to ensure that failure or damage to a system will not cause immediate complete loss of the system. Systems are to be capable of accommodating progressive actions (manual and/or automatic) that will provide availability of supply to ~~essential services~~ Mobility and/or Ship Type systems for agreed periods of time in the event of action damage.

■ *Section 4* Control arrangements

4.1 General

4.1.3 Where isolation of ~~essential services~~ Mobility systems or Ship Type systems is to be carried out whether automatically or manually, indication of the status of isolation is to be provided at each control station.

Volume 2, Part 7, Chapter 5

■ *Section 7*
Chilled water systems

7.1 General

7.1.5 Where chilled water is used to provide a controlled environment for equipment and machinery intended for ~~essential services~~ Mobility and/or Ship Type systems which require this controlled environment to function, an alternative means is to be provided to maintain the required environment in the event of a failure of the chilled water system. Failure of the chilled water system is to initiate an alarm. Duplication of the equipment requiring cooling can be provided instead of an alternative means of cooling, providing that the duplicated equipment is fed from an alternative, independent chilled water system.

■ *Section 11*
Hydraulic power actuating systems

11.1 General

11.1.2 The arrangements for storage, distribution and utilisation of hydraulic and flammable oils employed under pressure in power transmission systems, control and actuating systems, heating systems and hydraulic media in systems which are ~~providing essential services~~ part of Mobility systems or Ship Type systems, are to comply with the requirements of this Section.

Volume 2, Part 8, Chapter 1

Steam Raising Plant and Associated Pressure Vessels

Effective date 1 January 2016

■ *Section 15*
Mountings and fittings for cylindrical and vertical boilers, steam generators, pressurised thermal liquid and pressurised hot water heaters

15.2 Safety valves

15.2.8 For each safety valve, an individual unrestricted drain is to be provided. The drain pipe is to be fitted to the lowest part of the discharge side of the safety valve ~~chest~~; it is to be below the level of the valve seat and is to be independently led with a continuous fall to a place where the high temperature steam and/or condensate can discharge, visibly clear of the boilers, and where it cannot cause injury. No valves or cocks are to be fitted to these drain pipes. The bore of the drain pipes is not to be less than 19 mm. Where a drain pipe of 19 mm is impracticable, smaller drain pipes may be considered.

15.5 Stop valves

15.5.2 Where two or more boilers are connected together:

- Stop valves of self-closing or non-return type are to be fitted.
- ~~Essential services~~ Mobility and/or Ship Type systems are to be capable of being supplied from at least two boilers.

15.8 Feed check valves

15.8.1 Two feed check and stop valves, connected to separate feed lines, are to be provided for all main and auxiliary boilers which are required for ~~essential services~~ Mobility and/or Ship Type systems. The feed check and stop valves may be connected to a single standpipe at the shell. In the case of steam/steam generators one feed check valve is acceptable provided steam for ~~essential services~~ Mobility and Ship Type systems is simultaneously available from another source.

Volume 2, Part 9, Chapter 1

General Requirements for the Design and Construction of Electrotechnical Systems

Effective date 1 January 2016

■ *Section 1*
General requirements

1.1 Scope

1.1.2 Electrical services required to maintain the ship in a normal sea-going, operational and habitable condition are to be capable of being maintained without recourse to the emergency source of electrical power. The ~~essential services~~ Mobility and/or Ship Type systems for individual types of ships for sea-going, operational and habitable conditions on board are to be agreed by Lloyd's Register (hereinafter referred to as 'LR'). *See also* Vol 2, Pt 1, Ch 1, 3.1 Categories, Vol 2, Pt 1, Ch 1, 3.1 Categories and Vol 2, Pt 1, Ch 1, 3.1 Categories.

1.2 Application

1.2.8 Equipment shall be selected with due regard to its required strength and capability. System design is to ensure that, under normal operation and foreseeable abnormal conditions, the equipment's strength and capability is not exceeded in such a way as may give rise to danger or may affect other ~~essential services~~ Mobility or Ship Type systems.

1.3 Definitions

1.3.1 Reference is to be made ~~toVol 2, Pt 1, Ch 3, 15 Steering systems and Vol 2, Pt 1, Ch 3, 16 Sea trials~~ to Vol 2, Pt 1, Ch 1, 3 Engineering system designation defining ~~essential services~~ Mobility and Ship Type systems, services considered necessary for minimum comfortable conditions of habitability and services considered necessary to maintain the ship in a normal seagoing, operational and habitable condition.

1.4 Documentation required for design review

(*Part only shown*)
1.4.2 A description of operation (with explanatory diagrams), schematic diagrams of circuits, and lists of monitored parameters with relevant setpoints:

- Propulsion machinery ~~including essential auxiliaries~~ and auxiliaries for Mobility and/or Ship Type Systems.

(*Part only shown*)
1.4.17 A schedule of batteries fitted for use for emergency, ~~and essential services~~ Mobility and/or Ship Type systems, giving details of:

1.5 Documentation required for supporting evidence

(*Part only shown*)
1.5.1 The documentation in Vol 2, Pt 9, Ch 1, 1.5 Documentation required for supporting evidence is to be submitted as supporting evidence.

- section boards and distribution boards supplying ~~essential~~ Mobility and/or Ship Type systems, and emergency services;

1.5.4 A Risk Assessment (RA), in accordance with Vol 2, Pt 1, Ch 3, 17 Risk Assessment (RA), is required to be submitted, *see* Vol 2, Pt 1, Ch 3, 3.3 Calculations and specifications. The RA is to verify the availability of electrical power to ~~essential services~~ Mobility and/or Ship Type systems in the event of a failure of a system or item of equipment, *see* Vol 2, Pt 9, Ch 3, 4.2 Essential services.

1.6 Surveys

1.6.2 The following equipment, where intended for use for ~~essential~~ Mobility systems, Ship Type systems, and/or emergency services, is to be surveyed by the Surveyors during manufacture and testing:

- Converting equipment of 100 kW and over;
- Rotating machines of 100 kW and over;
- Switchboards and section boards; and
- UPS units of 50 kVA and over.

1.6.5 All other electrical equipment, not specifically referenced in Vol 2, Pt 9, Ch 1, 1.6 Surveys and Vol 2, Pt 9, Ch 1, 1.6 Surveys, intended for use for ~~essential~~ Mobility systems, Ship Type systems, or emergency services is to be supplied with a manufacturer's works test certificate showing compliance with the constructional standard(s) as referenced by the relevant requirements of the Chapter.

■ *Section 2*
System level requirements

2.1 Quality of power supplies (QPS)

2.1.1 All electrical equipment supplied from the main and emergency sources of electrical power and electrical equipment for ~~essential~~ Mobility systems, Ship Type systems, and emergency services supplied from d.c. sources of electrical power is to be so designed and manufactured that it is capable of operating satisfactorily under normally occurring variations of voltage and frequency.

2.2 Design, construction and location

2.2.5 Where equipment intended for ~~essential services~~ Mobility or Ship Type systems requires a controlled environment, an alternative means is to be provided to maintain the required environment in the event of a failure of the normal cooling system. Failure of the cooling system is to initiate an alarm. Duplication of the equipment requiring cooling can be provided instead of an alternative means of cooling, providing that the duplicated equipment is fed from an alternative, independent cooling system.

2.2.9 Switchboards, section boards and distribution boards supplying ~~essential~~ Mobility or Ship Type systems, and emergency services, as well as cables from the respective generators to and between these boards, are to be arranged to avoid areas of high fire risk and elevated temperatures, for example, in close proximity to incinerators and boilers.

2.2.21 Where electrical power is used for propulsion, the equipment is to be so arranged that it will operate satisfactorily in the event of partial flooding by bilge water above the tank top up to the bottom floor plate level under the normal angles of inclination given in Vol 2, Pt 9, Ch 1, 2.3 Ambient reference and operating conditions for ~~essential electrical equipment~~ Mobility systems, *see* Vol 2, Pt 7, Ch 2, 4 Drainage of machinery spaces. This requirement excludes military aspects that are required to be defined by Vol 2, Pt 1, Ch 3, 4.9 Military requirements.

2.3 Ambient reference and operating conditions

2.3.1 Reference is to be made to Vol 2, Pt 1, Ch 3, 4.4 Ambient reference conditions and Vol 2, Pt 1, Ch 3, 4.5 Ambient operating conditions for the requirements concerning: Ambient reference conditions and Ambient operating conditions, with regards to the rating of ~~essential electrical equipment~~ Mobility and/or Ship Type electrical equipment for classification of restricted and unrestricted service conditions, and satisfactory operating conditions of ~~main and essential auxiliary~~ machinery Mobility and/or Ship Type systems.

2.3.4 Equipment used for cooling and maintaining the lesser ambient temperature in accordance with Vol 2, Pt 9, Ch 1, 2.3 Ambient reference and operating conditions are considered ~~essential services~~ Mobility or Ship Type systems and are to satisfy the requirements of Vol 2, Pt 9, Ch 3, 4.2 Essential services.

■ *Section 4*
Unattended machinery space(s) — UMS notation

4.1 General

(*Part only shown*)
4.1.1 Where it is proposed to operate the following machinery in an unattended space, no matter what period is envisaged, the controls, alarms and safeguards required by the appropriate Chapters together with those given in Vol 2, Pt 9, Ch 1, 4.2 Alarm systems for machinery to Vol 2, Pt 9, Ch 1, 4.7 Supply of electric power, general are to be provided:

- ~~Propulsion machinery including essential auxiliaries~~ Mobility systems.

4.7 Supply of electric power, general

4.7.1 For naval ships operating with one generator set in service, arrangements are to be such that a standby generator will automatically start and connect to the switchboard in as short a time as practicable, but in any case within 45 seconds, on loss of the service generator. For naval ships operating with two or more generator sets in service, arrangements are to be such that on loss of one generator the remaining one(s) are to be adequate for continuity of ~~essential services~~ Mobility and/or Ship Type systems. For the detailed requirements of these arrangements, *see* Vol 2, Pt 9, Ch 2, 4.2 Number and rating of generators and converting equipment

Volume 2, Part 9, Chapter 2

Electrical Power Generator and Energy Storage

Effective date 1 January 2016

■ *Section 2*
Performance requirements

2.1 Performance requirements

2.1.2 System design intent shall provide for sufficient electrical power to supply ~~essential services~~ Mobility systems, Ship Type systems, and habitable conditions in the event of loss or unavailability of any one generating set.

■ *Section 4*
Main source of electrical power

4.2 Number and rating of generators and converting equipment

4.2.1 Under seagoing conditions, the number and rating of service generating sets and converting sets, such as transformers and semi-conductor converters, when any one generating set or converting set is out of action, are:

- (a) to be sufficient to ensure the operation of electrical services for ~~essential equipment~~ Mobility systems, Ship Type systems, and habitable conditions. *See* Vol 2, Pt 4, Ch 5, 4.3 Power requirements for electric propulsion systems;
- (b) to have sufficient reserve capacity to permit the starting of the largest motor without causing any motor to trip, stall or any device to fail due to excessive voltage drop on the system;
- (c) to be capable of providing the electrical services necessary to start the main propulsion machinery from a dead ship condition. The emergency source of electrical power may be used to assist if it can provide power at the same time to those services required to be supplied by Vol 2, Pt 9, Ch 2, 5 Emergency and alternative sources of electrical power

4.2.2 The arrangement of the ship's main source of power is to be such that the operation of electrical services for ~~essential equipment~~ Mobility systems, Ship Type systems, and habitable conditions can be maintained regardless of the speed and direction of the propulsion machinery shafting.

4.2.3 Arrangements are to be provided to prevent overloading of the generating set(s) supplying the electrical power that is/are required to maintain the ship in a normal operational and habitable condition. On loss of electrical power, arrangements are to be made for a standby generator set to be started, connected to the switchboard and ~~essential services~~ Mobility systems and Ship Type systems restarted in as short a time as is practicable. These load control, starting and restart functions may be achieved by the actions of suitably trained personnel but in ships with **UMS** notation the arrangements are to be automatic, *see also* Vol 2, Pt 9, Ch 4, 4.9 Load management.

4.5 Main propulsion driven generators not forming part of the main source of electrical power

4.5.3 Where there is remote control of the propulsion machinery, arrangements are to ensure that ~~essential~~ Mobility machinery power supplies are maintained during manoeuvring conditions in order to prevent a blackout situation.

■ *Section 7*
Batteries

7.7 Recording of batteries for emergency and essential services

7.7.1 A schedule of batteries fitted for use for ~~essential~~ Mobility systems, Ship Type systems, and emergency services is to be compiled and maintained.

7.7.3 When additions or alterations are proposed to the existing batteries for ~~essential~~ Mobility systems, Ship Type systems, and emergency services, the schedule and replacement procedure documentation are to be updated to reflect the proposed installation and submitted in accordance with Vol 2, Pt 9, Ch 1, 1.7 Alterations and additions.

Volume 2, Part 9, Chapter 3

Electrical Power Distribution and Equipment

Effective date 1 January 2016

■ *Section 2*
Performance requirements

2.1 Performance requirements

2.1.10 The continuity of supply to ~~essential services~~ Mobility and/or Ship Type systems is to be ensured under normal operation and defined abnormal conditions.

2.1.18 Alternative arrangements for cooling of ~~essential machinery and~~ Mobility and/or Ship Type systems in the event of a forced cooling system failure shall be provided.

■ *Section 4*
Supply and distribution

4.2 Essential services

4.2.1 ~~Essential services~~ Mobility or Ship Type systems that are required to be duplicated are to be served by individual circuits, separated in their switchboard or section board and throughout their length as widely as is practicable without the use of common feeders, protective devices, control circuits or controlgear assemblies, so that any single fault will not cause the loss of both services.

4.2.2 Where Vol 2, Pt 9, Ch 3, 4.2 Essential services is applicable the main busbars of the switchboard, or section boards, are to be capable of being split, by a multi-pole linked circuit breaker, disconnector or switch-disconnector, into at least two independent sections, each supplied by at least one generator, either directly or through a converter. The ~~essential services~~ Mobility and/or Ship Type systems are to be equally divided, as far as is practicable, between the independent sections.

4.2.3 Where Vol 2, Pt 9, Ch 3, 4.2 Essential services is applicable provision is to be made to transfer to a temporary circuit those ~~essential services~~ Mobility and/or Ship Type systems which are not required to be, and have not been, duplicated in the event of loss of their normal section of switchboard or section-board.

4.2.4 A Risk Based Assessment (RA) is to be carried out in accordance with the requirements of Vol 2, Pt 1, Ch 3, 17 Risk Assessment (RA). The RA is to verify the availability of electrical power to ~~essential services~~ Mobility and/or Ship Type systems (*see* Vol 2, Pt 1, Ch 1, 3.1 Categories) in the event of a failure in the power supply and distribution system. The RA is to address the different system operating modes and configurations. The RA should include relevant mechanical failures which may have significant effects on the electrical power and distribution system, i.e. prime mover failures causing loss of electrical power supplies ~~used~~ to ~~provide essential services~~ Mobility and/or Ship Type systems. An analysis carried out by applying the relevant generic failure modes listed in IEC 60812:1985, Analysis techniques for system reliability - Procedure for failure mode and effects analysis (FMEA) to the system and equipment identified in the single line diagram of the electrical system (*see* Vol 2, Pt 9, Ch 1, 1.4 Documentation required for design review) would generally be acceptable.

4.8 Motor circuits

4.8.1 A separate final sub-circuit is to be provided for every motor for ~~essential services~~ Mobility and/or Ship Type systems, *see* Vol 2, Pt 1, Ch 1, 3.1 Categories.

■ *Section 5*
Switchgear and controlgear assemblies

5.3 Circuit-breakers

5.3.6 Air circuit-breakers for ~~essential~~ Mobility systems, Ship Type systems, or emergency services and rated at 800 A and above are to have a cumulative count kept of the switching operations of the electrical contacts. This count, along with the manufacturer's details for the circuit-breaker, including the maximum number of switching operations for the electrical contacts, is to be retained on board. These details are to be made available to the Surveyor on request.

Volume 2, Part 9, Chapter 3

■ *Section 6*

Rotating machines – general requirements and motors

6.1 General requirements

6.1.3 All machines of 100 kW and over, intended for ~~essential services~~ Mobility or Ship Type systems, are to be surveyed by the Surveyor during manufacture and test.

(*Part only shown*)
6.1.4 Shaft materials for rotating machines for ~~essential services~~ Mobility or Ship Type systems are to comply with the *Rules for Manufacture, Testing and Certification of Materials* (hereinafter referred to as the Rules for Materials) and are to be manufactured under LR survey for the following applications:

6.7 Survey and testing

6.7.1 On machines for ~~essential services~~ Mobility or Ship Type systems, tests are to be carried out and a certificate furnished by the manufacturer. The tests are to include temperature rise, momentary overload, high voltage, and commutation. The insulation resistance and the temperature at which it was measured are to be recorded, *see also* Vol 2, Pt 9, Ch 1, 1.6 Surveys.

■ *Section 7*

Converter equipment

7.3 Uninterruptible power systems

7.3.1 The requirements of this sub-Section apply to all uninterruptible power systems (UPS) intended to maintain ~~essential services~~ Mobility or Ship Type systems, or provide emergency services. This sub-Section is in addition to the requirements of Vol 2, Pt 9, Ch 3, 7.1 Transformers to Vol 2, Pt 9, Ch 3, 7.2 Semiconductor converters and Vol 2, Pt 9, Ch 2, 7 Batteries, as applicable.

■ *Section 8*

Electric cables, optical fibre cables and busbar trunking systems (busways)

8.8 Installation of electric cables

8.8.4 Electric and optical fibre cables for ~~essential~~ Mobility systems, Ship Type systems, and emergency services are to be arranged, so far as is practicable, to avoid galleys, machinery spaces and other enclosed spaces and areas of high fire risk except as is necessary for the service being supplied. Such cables are also, so far as reasonably practicable, to be routed clear of bulkheads to preclude them being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.

8.8.19 Electric and optical fibre cables serving any ~~essential services~~ Mobility or Ship Type system, and any glands through which they pass must be able to withstand flooding for a period of 18 hours, based on the water pressure that may occur at the location.

8.17 Busbar trunking systems (bustrunks)

8.17.4 Where the busbar trunking system is employed for circuits on and below the bulkhead deck, arrangements are to be made to ensure that circuits on other decks are not affected in the event of partial flooding under the normal angles of inclination given in Vol 2, Pt 1, Ch 1, 4.4 Installation, integration and test principles. and Vol 2, Pt 1, Ch 1, 4.5 Trials principles for ~~essential electrical equipment~~ Mobility or Ship Type systems.

■ *Section 10*

Navigation and manoeuvring systems

10.3 Thruster systems for manoeuvring

10.3.1 Where a thruster unit is fitted solely for the purpose of manoeuvring, and is electrically driven, its starting and operation is not to cause the loss of any ~~essential services~~ Mobility systems or Ship Type systems.

Volume 2, Part 9, Chapter 4

Electrical Protection

Effective date 1 January 2016

■ *Section 4*
System design - protection

4.1 General

4.1.1 Installations are to be protected against overcurrents including short-circuits, and other electrical faults. The tripping/fault clearance times of the protective devices are to provide complete and co-ordinated protection to ensure:

(a) availability of ~~essential~~ Mobility systems, Ship Type systems, and emergency services under fault conditions through discriminative action of the protective devices; as far as practicable the arrangements are also to secure the availability of other services;
(b) elimination of the fault to reduce damage to the system and hazard of fire~~.~~;
(c) uninterrupted electrical supply during normal operation of the system including motor starting and similar transient overcurrent conditions.

4.1.3 The protection of circuits is to be such that a fault in a circuit does not cause the interruption of supplies used to provide emergency, ~~or essential services~~ Mobility systems or Ship Type systems other than those dependent on the circuit where the fault occurred. For circuits used to provide ~~essential services~~ Mobility or Ship Type systems which need not necessarily be in continuous operation to maintain propulsion and steering but which are necessary for maintaining the vessel's safety, arrangements that ensure that a fault in a circuit does not cause the sustained interruption of supply to healthy circuits may be accepted. Such arrangements are to ensure the supply to healthy circuits is automatically re-established in sufficient time after a fault in a circuit.

4.7 General

4.7.2 The same device may back-up more than one circuit-breaker provided that no ~~essential~~ Mobility systems, Ship Type systems, or emergency service is supplied from there, or that any such service is duplicated by arrangements unaffected by tripping of the device.

4.8 Protection of generators

4.8.7 The protection of electrical power generation and distribution systems is to be so arranged that, in the event of failure of a protection device, including integrated multifunction relays, sufficient power can be supplied to all ~~essential services~~ Mobility and/or Ship Type systems, *see also* Vol 2, Pt 9, Ch 3, 4.2 Essential services.

4.9 Load management

4.9.3 If required, this load switching may be carried out in one or more stages, in which case ~~the non-essential~~ circuits other than Mobility or Ship Type systems are to be included in the first group to be disconnected.

4.11 Motor circuits

4.11.1 Motors of rating exceeding 0,5 kW and all motors for ~~essential services~~ Mobility or Ship Type systems are to be protected individually against overload and short circuit. Motors for ~~services essential~~ Mobility or Ship Type systems for the safety and propulsion of the ship and which are duplicated are to be provided with arrangements to start the standby motor and disconnect the faulty motor. Such motors may have an overload alarm instead of overload protection. The actions to start the standby motor and disconnect the faulty motor may be carried out by suitably trained personnel but in ships with **UMS** notation the arrangements are to be automatic.

■ *Section 6*
Protection of electrical equipment against the effects of lightning strikes

6.1 General

6.1.1 Precautions are to be taken to protect ~~essential~~ Mobility and/or Ship Type systems electronic equipment that may be susceptible to damage from voltage pulses attributable to the secondary effects of lightning. This may be achieved by suitable design and/or the use of additional protective devices, such as surge arrestors. Resultant induced voltages may be further reduced by the use of earthed metallic screened cables.

Volume 2, Part 9, Chapter 7

Control, Alerts and Safety Systems

Effective date 1 January 2016

■ *Scope*

The requirements of this Chapter are applicable to the design and construction philosophy of machinery control, alert and safety systems as well as ship safety systems that are essential to the safety of a naval vessel.

This Chapter details the requirements for hard wired, solid state and programmable electronic systems within the boundary for provision of ~~essential services~~ Mobility and/or Ship Type systems.

Application of this Chapter will facilitate the verification of the performance requirements of *ANEP-77 NATO Naval Ship Code*, Chapter IV, Regulations 13, 14 and 15.

■ *Section 1*
Functional requirements

1.1 Functional requirements

1.1.1 Systems ~~essential~~ for propulsion~~,~~ and manoeuvring, and electrical power generation and safety of the ship shall be provided with effective means of control and alert to ensure fault identification and safe operation under all ship operational conditions.

1.1.2 Alert systems shall inform Operators as soon as reasonably practicable of deviations from normal operation of ~~essential machinery and~~ Mobility and/or Ship Type systems during all ship operations.

■ *Section 2*
Performance requirements

2.1 Performance requirements

2.1.2 Mobility Systems ~~essential~~ for propulsion~~,~~ and manoeuvring, electrical power generation, and safety of the ship shall be provided with a continuous electrical supply. An audible and visual alert shall be initiated in the event of the failure of any of the power supplies.

2.1.3 The control system must operate ~~essential machinery~~ Mobility and/or Ship Type systems in a safe, controlled and stable manner throughout the machinery's/systems' defined operational limits and shall recover automatically in a safe manner after a loss of power supply.

2.1.6 Means are to be available to disable the automatic or remote control operation of ~~essential machinery~~ Mobility and/or Ship Type systems to allow inspection and maintenance tasks to be performed safely on the machinery and systems.

2.1.7 Indications of impending slowdown/shutdown of ~~essential machinery~~ Mobility and/or Ship Type systems shall be provided at applicable locations with provision to take alternative actions if approved.

2.1.8 Automated control systems which utilise stored energy to start ~~essential~~ Mobility and/or Ship Type machinery shall be configured not to exhaust the stored energy completely and to provide an alert when the stored energy is below a critical limit.

2.1.10 Where it is proposed to operate the ~~essential~~ Mobility or Ship Type machinery in an unattended space, no matter what period, sufficient controls, alarms and safeguards are to be provided to enable safe and effective operation of the equipment. A dedicated control position shall be provided.

2.1.11 Failure of a control system is not to result in the loss of ability to provide ~~essential services~~ either Mobility or Ship Type systems by alternative means.

2.1.13 Operators shall have an independent, high integrity method to disconnect all energy sources that shall put machinery for ~~essential~~ Ship Type safety functions into a known safe state.

Volume 2, Part 9, Chapter 7

■ *Section 4*
Essential features for control, alarm and safety systems

4.1 General

4.1.1 This Chapter applies to systems providing control, alarm or safety functions for the following:

- ~~Main propulsion systems.~~
- ~~Steering and manoeuvring systems.~~
- ~~Electrical power systems.~~
- ~~Essential auxiliary machinery systems.~~
- ~~Other engineering systems necessary for the watertight and weathertight integrity of the ship and functioning of ship type category systems.~~
- Mobility category engineering systems.
- Ship Type category engineering systems.

4.5 Control systems, general requirements

4.5.7 Failure of a control system is not to result in the loss of ability to provide ~~essential services~~ Mobility and/or Ship Type systems by alternative means. This may be achieved by manual control or redundancy within the control system or redundancy in machinery and equipment, *see also* Vol 2, Pt 9, Ch 8, 5.5 Additional requirements for integrated systems. Instrumentation is to be provided at local manual control stations to ensure effective operation of the machinery by duty personnel.

Volume 2, Part 9, Chapter 8

Programmable Electronic Systems

Effective date 1 January 2016

■ *Scope*

The requirements of this Chapter are applicable to the design and construction philosophy of Programmable Electronic Systems used for machinery control, alert and safety systems as well as ship safety systems that are essential to the safety of a naval vessel.

This Chapter details the requirements for programmable electronic systems within the boundary for provision of ~~essential services~~ both Mobility and Ship Type systems.

Application of this Chapter will facilitate the verification of the performance requirements of *ANEP-77 NATO Naval Ship Code*, Chapter IV, Regulation 15.

■ *Section 5*
Programmable electronic systems (PES)

5.1 General requirements

5.1.1 The requirements of this Section are to be complied with where control, alarm or safety systems incorporate programmable electronic equipment. ~~Systems for essential services~~ Mobility systems, Ship Type systems and safety critical systems incorporating shared data communication links and systems which are integrated are to comply with the additional ~~the~~ requirements of Vol 2, Pt 9, Ch 8, 5.2 Data communication links, Vol 2, Pt 9, Ch 8, 5.3 Additional requirements for wireless data communication links and Vol 2, Pt 9, Ch 8, 5.4 Additional requirements for Mobility category and safety critical systems as applicable.

5.1.13 Where regular battery replacement is required to maintain the availability of volatile memory back-up power supply required by Vol 2, Pt 9, Ch 8, 5.1 General requirements, these are to be included in the schedule of batteries required by Vol 2, Pt 9, Ch 1, 1.4 Documentation required for design review and Vol 2, Pt 9, Ch 2, 7.7 Recording of batteries for emergency and essential services, irrespective of battery type and size. Applicable entries in this schedule are to note that these batteries are not for safety critical systems, ~~or essential~~ Mobility systems, Ship Type systems, or emergency services.

Volume 2, Part 9, Chapter 8

5.1.21 Software lifecycle activities, e.g. design, development, supply and maintenance, are to be carried out in accordance with an acceptable quality management system. Software quality plans are to be submitted. These are to demonstrate that the provisions of ISO/IEC 90003:2014 *Software engineering – Guidelines for the application of ISO 9001:~~2000~~ 2008 to computer software* or an acceptable International, National or naval standard, are incorporated. The plans are to define responsibilities for the lifecycle activities, including verification, validation, module testing and integration with other components or systems.

5.2 Data communication links

5.2.2 Data communication is to be automatically restored within 45 seconds in the event of a single component failure. Upon restoration, priority is to be given to updating safety critical data and control, alarm and safety related data for ~~essential services~~ Mobility and/or Ship Type systems. Components comprise all items required to facilitate data communication, including cables, switches, repeaters, software components and power supplies.

5.2.3 Loss of a data communication link is not to result in the loss of ability to operate any ~~essential service~~ Mobility or Ship Type system by alternative means, *see also* Vol 2, Pt 9, Ch 8, 5.4 Additional requirements for Mobility category and safety critical systems.

5.3 Additional requirements for wireless data communication links

5.3.2 Wireless data communication links are not to be used for safety critical systems, ~~or essential services~~ Mobility systems or Ship Type systems that are required for the propulsion or safety of the ship, except as permitted by Vol 2, Pt 9, Ch 8, 5.3 Additional requirements for wireless data communication links.

5.4 Additional requirements for Mobility category and safety critical systems

5.4.5 For ~~essential services~~ Mobility and/or Ship Type, the system is to be arranged to operate automatically from an alternative power supply in the event of a failure of the normal supply.

5.5 Additional requirements for integrated systems

5.5.5 Where the integration involves control functions for ~~essential services~~ Mobility systems, Ship Type systems, or safety functions, including fire safety or crew and embarked personnel or emergency safety functions, the Risk Assessment (RA) required by Vol 2, Pt 1, Ch 3, 3.3 Calculations and specifications is to additionally ~~to~~ demonstrate that the integrated system will 'fail-safe', *see* Vol 2, Pt 9, Ch 7, 4.4 Safety systems, general requirements and Vol 2, Pt 9, Ch 7, 4.5 Control systems, general requirements, and that ~~essential services~~ Mobility and/or Ship Type systems in operation will not be lost or degraded beyond acceptable performance criteria where specified by these Rules.

Volume 2, Part 9, Chapter 9

Fire Safety and Ship Safety Systems

Effective date 1 January 2016

■ *Section 2*
Performance requirements

2.1 Performance requirements

2.1.8 The activation of detection or extinction systems shall not result in the loss of ~~essential services~~ Mobility and/or Ship Type systems.

■ *Section 5*
Fire safety systems

5.2 Fixed water-based local application fire-fighting systems

5.2.7 System zones and protected areas are to be arranged to allow ~~essential services~~ Mobility and/or Ship Type systems to be provided by machinery and/or equipment located outside areas affected by direct spray or extended water in the event of a system activation, where the machinery and/or equipment is duplicated or otherwise replicated to provide redundancy.

5.2.16 The evidence required by Vol 2, Pt 9, Ch 9, 5.2 Fixed water-based local application fire-fighting systems is to demonstrate the safe and effective operation of the overall arrangements in the event of system operation. This evidence is to demonstrate that exposure to system spray and/or water:

- cannot result in loss of ~~essential services~~ Mobility or Ship Type systems (e.g. unintended activation of automatic machinery shutdown);

Volume 2, Part 9, Chapter 9

- cannot result in loss of availability of emergency services;
- will not affect the continued safe and effective operation of electrical and electronic equipment required to operate during the required period of system operation;
- does not present additional electrical or fire hazards; and
- would require only identified readily replaceable components to be repaired or replaced.

The installation of electrical and electronic equipment required to provide ~~essential~~ Mobility systems, Ship Type systems, or emergency services in enclosures with a degree of protection less than IP44 within areas exposed to direct spray is to be acceptable to LR, and evidence of suitability is to be submitted accordingly.

5.8 ~~Fire-extinguishing~~ Fire extinguishing media release

5.8.2 The arrangements for accessing and activating the release of ~~fire-extinguishing~~ fire extinguishing media are not to automatically shut off fuel oil, lubricating oil or hydraulic oil to Mobility machinery ~~essential~~ required for the propulsion and the safety of the ship, *see* Vol 2, Pt 1, Ch 1, 3.1 Categories.

Volume 2, Part 9, Chapter 11

Testing and Trials

Effective date 1 January 2016

■ *Section 1*
Testing and trials

1.2 Trials

(*Part only shown*)

1.2.7 It is to be demonstrated that the Rules have been complied with in respect of:

(h) all ~~essential~~ Mobility systems, Ship Type systems, and other important equipment are to be operated under service conditions, though not necessarily at full load or simultaneously, for a sufficient length of time to demonstrate that they are satisfactory;

Volume 2, Part 10, Chapter 1

Ergonomics

Effective date 1 January 2016

■ *Section 6*
Ergonomics of control stations

6.3 Operator interface

6.3.1 The requirements of Vol 2, Pt 10, Ch 1, 6.3 Operator interface apply to operator interfaces for ~~essential~~ Mobility and/or Ship Type engineering systems located either locally, remotely or within the main control room. The requirements are intended to enhance the usability of systems and equipment, reduce human error, enhance situational awareness and support safe and effective monitoring and control under normal and abnormal modes of operation.

6.4 Controls

6.4.1 The requirements of Vol 2, Pt 10, Ch 1, 6.4 Controls apply to operator interfaces for ~~essential~~ Mobility and/or Ship Type engineering systems located either locally, remotely or within the main control room. The requirements are intended to enhance the usability of systems and equipment, reduce human error, enhance situational awareness and support safe and effective monitoring and control under normal and abnormal modes of operation.

6.5 Displays

6.5.1 The requirements of Vol 2, Pt 10, Ch 1, 6.5 Displays apply to operator interfaces for ~~essential~~ Mobility and/or Ship Type engineering systems located either locally, remotely or within the main control room. The requirements are intended to enhance the usability of systems and equipment, reduce human error, enhance situational awareness and support safe and effective monitoring and control under normal and abnormal modes of operation.

■ *Section 7*
Ergonomics of lighting

7.1 Positioning and installation

~~7.1.4~~ 7.1.7 Lights are to be positioned taking account of air-conditioning vents or fans, fire detectors, water sprinklers, etc. so the lighting is not blocked by these items.

~~7.1.6~~ 7.1.4 Lights are to be positioned so as to reduce bright spots and shadows as far as possible.

~~7.1.7~~ 7.1.8 The position~~ing~~ of ~~fluorescent tubes is~~ lights configured to strips or tubes is, as far as practicable, to be at right angles to an Operator's line of sight while the Operator is located at their typical duty station ~~as far as practicable~~.

~~7.1.8~~ 7.1.9 Any physical hazards that provide a risk to operator safety are to be appropriately illuminated.

~~7.1.9~~ 7.1.10 The positioning of lights is to consider the transfer of heat to adjacent surfaces.

~~7.1.10~~ 7.1.6 Lights are not to be positioned in locations which would result in ~~a significant reduction in~~ limited illumination.

7.1.11 Lights are ~~not~~ to be positioned in locations that are ~~difficult~~ easy to reach for bulb replacement or maintenance.

7.2 ~~Illuminance~~ Luminance distribution

7.2.1 In order to provide even, fatigue-free illumination the requirements of Vol 2, Pt 10, Ch 1, ~~7.3 Glare~~ 7.2.2 to 7.2.6 are to be complied with.

7.2.5 Where required for operational tasks, local lighting is to be provided in addition to general lighting ~~for operational tasks~~.

7.3 Glare

7.3.1 In order to minimise glare (to avoid dazzle, discomfort and fatigue), the requirements of Vol 2, Pt 10, Ch 1, 7.3 Glare are to be complied with.

~~7.3.3~~ 7.3.4 Where necessary, suitable blinds and shading devices are to be used to prevent glare.

~~7.3.4~~ 7.3.3 ~~The placement of controls, displays and indicators are to consider the position of lights relative to the Operator, in their normal working position, with respect to reflections and evenness of lighting.~~ Lights are to be positioned so as to provide even illumination and minimal glare on controls, displays and indicators.

7.4 Location of lighting controls and outlets

7.4.1 In order to allow convenient use of lighting the requirements of Vol 2, Pt 10, Ch 1, ~~7.4 Location of lighting controls and outlets~~ 7.4.2 to 7.4.6 are to be complied with.

7.4.2 The lighting system is to be easily ~~maintainable~~ maintained and ~~operable~~ operated by personnel.

7.4.3 Lighting is to be controllable locally in accommodation and working areas, except where this conflicts with safety requirements.

7.4.4 Light switches are to be fitted in ~~positions which are safe for personnel~~ easily accessible locations where safe and effective operation is possible.

7.4.6 Power outlets are to be provided ~~for~~ where temporary, local, task lighting~~, for example in accommodation areas, work spaces and internal and external walkways~~ will be required, except in hazardous areas.

7.5 Night vision

7.5.1 In order to maintain night vision and facilitate safety during hours of darkness, the requirements of Vol 2, Pt 10, Ch 1, ~~7.5 Night vision and Vol 2, Pt 10, Ch 1, 7.5 Night vision~~ 7.5.2 to 7.5.10 are to be complied with.

7.5.2 Lighting on the ship's superstructure is to be directed away from, and shaded to prevent direct illumination of, the bridge windows and lookout points. Attention is drawn to the requirements of International Regulations for Preventing Collisions at Sea (COLREGS) with regard to exhibition of lights other than navigation lights.

7.5.3 Lookout positions are to offer shading from direct illumination by off-ship operations.

Existing paragraphs 7.5.2 *to* 7.5.7 *have been renumbered* 7.5.4 *to* 7.5.9.

~~6.5.8~~ 7.5.10 ~~All illumination and lighting~~ Lighting of instruments, keyboards and controls are to be adjustable down to zero, except for the lighting of alarm and warning indicators and the controls of dimmers which are to remain readable.

Volume 2, Part 11, Chapter 1

Made and Fresh Water Systems

Effective date 1 January 2016

■ *Section 3*
System arrangements

3.3 Piping system design

3.3.1 Piping system arrangements are to be such that the supply of made and fresh water can be made to ~~essential~~ Mobility and/or Ship Type systems such as chilled water, machinery fresh water cooling and boiler feed water in the event of a single failure or damage of a system or item of equipment. As far as possible, permanent connections to these systems are to be avoided to prevent contamination of the fresh water by additives such as corrosion inhibitors that may be present in the systems. Where it is essential to fit permanent connections, means are to be provided to isolate the systems from the fresh water supplies to ensure that cross contamination cannot take place when the systems are operating normally.

Volume 2, Part 12, Chapter 1

Emissions Abatement Plant for Combustion Machinery

Effective date 1 January 2016

■ *Section 1*
General

1.1 Scope

1.1.1 The requirements of this Chapter apply to equipment fitted to combustion machinery in order to reduce emissions produced by the combustion of fuel. Such equipment is hereinafter referred to as emissions abatement plant. These requirements are intended to ensure that the emissions abatement plant is safe to operate and maintain and, additionally, where the combustion machinery provides power for ~~essential services~~ Mobility and/or Ship Type systems, that failure of the emissions abatement plant does not result in an unacceptable loss or degradation of those ~~essential services~~ systems. These requirements do not provide for the reliability or redundancy necessary to ensure continued operation of the emissions abatement plant, and thereby compliance with relevant emissions requirements, following failure of any equipment associated with the emissions abatement plant.

■ *Section 2*
Functional requirements

2.1 General

2.1.4 Where the emissions abatement plant is connected to combustion machinery providing power for ~~essential services~~ Mobility or Ship Type systems, failure, or the inability to operate the emissions abatement plant, is not to prevent the combustion machinery from delivering sufficient power to those ~~essential services~~ Mobility or Ship Type systems to ensure the safe operation of the ship.

■ *Section 3*
Information to be submitted

3.1 General

3.1.1 The information required by this Section and the information required by Vol 1, Pt 3, Ch 1, 4 Information required ~~and Ch 1 LR IV Information and Plans to be Submitted of the~~ ~~*Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquid Chemicals in Bulk*~~ ~~(hereinafter referred to as the Rules for Ships for Liquid Chemicals), as applicable~~ is to be submitted.

3.1.6 **Risk Based Analysis (RBA)**. The RBA required by Vol 2, Pt 1, Ch 3, 3.3 Calculations and specifications is to include consideration of the emissions abatement plant. It shall specifically detail the hazards associated with operation, maintenance and reasonably foreseeable failure of the emissions abatement plant and the means by which they are mitigated, demonstrating that the operation of ~~essential services~~ Mobility and/or Ship Type systems shall not be impaired by such scenarios. *See also* Vol 2, Pt 1, Ch 3, 17 Risk Assessment (RA).

3.3 Chemical substances

3.3.1 Details of the flammability, toxicity, corrosivity and reactivity of any chemicals used, together with details of any exothermic and hazardous reactions, particularly with regard to sea-water. This is to include effluent and sludge associated with emissions abatement plant and the corrosivity of wash water for wet scrubbing systems.

3.3.3 Details of arrangements for loading, storage, transfer and disposal of chemicals, by-products or waste products; this is to include allowable maximum and minimum storage temperatures for substances which are sensitive to temperature.

3.6 Pumping and piping

3.6.2 Diagrammatic plans for systems associated with emissions abatement process equipment, as required by Vol 2, Pt 7, Ch 1 Piping Design Requirements, Vol 2, Pt 7, Ch 2 Ship Piping System and Vol 2, Pt 7, Ch 3 Machinery Piping Systems ~~and by the Rules for Ships for Liquid Chemicals~~, as applicable.

■ *Section 4*
Materials

4.1 General

4.1.1 The materials used in the construction of the emissions abatement plant and any associated chemical and effluent storage tanks are to be manufactured and tested in accordance with the requirements of the Rules for the Manufacture, Testing and Certification of Materials ~~and/or the Rules for Ships for Liquid Chemicals~~.

4.1.2 Materials used in piping systems are to comply with Vol 2, Pt 7, Ch 1 Piping Design Requirements, Ch 2 Ship Piping System and Ch 3 Machinery Piping Systems as applicable.

4.1.3 Materials used for wet scrubbers are to be constructed of corrosion-resistant material which is suitable for the expected operating temperatures of the scrubber and for the properties of wash water and chemicals used in the process, *see* Vol 2, Pt 12, Ch 1, 3.3.1.

4.1.4 Materials used for selective catalytic reduction reactors are to be constructed of corrosion-resistant material which is to be suitable for the expected operating temperatures as well as the corrosive properties of ammonia and other chemicals associated with the chemical conversion process where applicable, *see* Vol 2, Pt 12, Ch 1, 3.3.1.

4.1.5 Materials used for the construction of tanks for chemical substances associated with emissions abatement plant are to be suitable at the temperature and pressure for the chemical substances to be carried in accordance with recognised standards. Where it is proposed to use corrosion-resistant tank lining or coating then such lining and coatings are to be confirmed as being suitable for the expected operating temperatures and corrosive properties of the chemicals to be carried within the tank.

4.1.6 Materials used for the construction of tanks for wash water and effluent are to be suitable for the expected corrosivity and temperature of wash water and effluent to be contained within such tanks. Where it is proposed to use corrosion-resistant tank lining or coating then such lining and coatings are to be confirmed as being suitable for the expected operating temperatures and corrosive properties of wash water and effluents.

■ *Section 5*
Hull construction

5.1 General

5.1.2 ~~All~~ Independent substance and effluent tanks ~~structures and their location relative to the ship's hull are to comply with Ch 2 Ship Survival Capability and Location of Cargo Tanks and Ch 4 Cargo Containment of the Rules for Ships for Liquid Chemicals, as applicable~~ are to be protected from mechanical damage. This may be achieved either by installation in spaces where there are no cargo or vehicle movements and where no heavy lifting operations are expected, or by mechanical protection if installed in spaces where such operations may take place.

5.1.3 Where necessary, the probable temperature variations during operations and the thermal stress considerations are to be stated. Where it is necessary either to heat or cool chemical storage tanks, the arrangements are to ~~meet the requirements of Ch 7 Cargo Temperature Control of the Rules for Ships for Liquid Chemicals.~~ utilise either active pipe coils or ducts for circulating a heating or cooling medium within the chemical storage tank or a heat exchanger through which the chemical and a heating or cooling medium are circulated. Active heating and cooling systems are to have capacity such that the chemical in the designated tanks can be maintained within the specified temperature limits, *see* Vol 2, Pt 12, Ch 1, 3.3.3, 3.4.4 and 7.1.10, under the following conditions:

	Heating systems	Cooling systems
Seawater temperature	0°C	32°C
Air temperature	5°C	45°C

Heating or cooling media are to be suitable for use with the specific chemical and consideration is to be given to the surface temperature of heating coils or ducts to avoid dangerous reactions from localised overheating or overcooling of chemicals. Heating or cooling systems are to be provided with valves to isolate the system for each tank and to allow manual regulation of flow along with a means for measuring the cargo temperature.

(*Part only shown*)
5.1.4 Where independent tanks are used for chemical substances, these are to be ~~bunded~~ arranged so as to contain ~~spillage~~ leakage. This may be achieved by using a double skinned storage tank, by means of a spill containment bund or by placing the tank in a dedicated compartment. Where a bund is to be used, it ~~The bund~~ is to comply with the following:
~~(c)~~ If the tank is located in a dedicated compartment ~~containing~~ then the compartment is to contain no equipment other than that required by the tank with permanent access and floor plates positioned above the liquid level if the tank were to discharge its full contents into the compartment. Any valves, equipment and emergency stop functions are to be operable from outside this compartment and are to meet the requirements of Vol 2, Pt 12, Ch 1, 5.2 Location service and control spaces. Tanks and spill containment arrangements are to be fitted with alarms and safeguards, in accordance with Table 1.9.1 Machinery emissions to air abatement plant: alarms and safeguards.

5.1.7 Chemical tanks containing substances which are categorised as a safety hazard in Chapter 17 of the Rules for Ships for Liquid Chemicals (designated by letter “S” in column d) are not to be located in the same space as essential machinery and equipment.

5.1.8 Arrangements for venting and gas-freeing chemical tanks required by emissions abatement plant are ~~to meet the requirements of Ch 8 Cargo Tank Venting and Gas-Freeing Arrangements of the Rules for Ships for Liquid Chemicals.~~ to meet the requirements of Vol 2, Pt 7, Ch 1 Piping Design Requirements, Ch 2 Ship Piping System and Ch 3 Machinery Piping Systems as applicable and are to be independent of the air pipes and venting systems of other tanks and/or compartments of the ship. Tank venting systems are to minimise the possibility of chemical vapour accumulating about the decks, entering accommodation, service and machinery spaces and control stations and, in the case of flammable vapours, entering or collecting in spaces or areas containing sources of ignition. Tank venting systems are to be arranged to prevent entrance of water into the chemical tanks. The venting systems shall be connected to the top of each chemical tank and as far as practicable are to be self-draining back to the chemical tanks under all normal operational conditions of list and trim.

5.1.9 Tank vent piping connected to cargo tanks of corrosion-resistant material, or to tanks which are lined or coated to provide corrosion resistance, are to be similarly lined or coated or constructed of corrosion-resistant material.

~~**5.4 Cofferdams**~~

~~5.4.1 Cofferdams are to be sited, as required by the Rules for Ships for Liquid Chemicals, as applicable, segregating any spaces in which chemicals, substances or effluents are stored or retained in bulk.~~

Existing sub-Sections 5.5 *to* 5.7 *have been renumbered* 5.4 *to* 5.6.

■ *Section 6*
Mechanical equipment

6.1 General

6.1.4 The emissions abatement plant is to be ~~capable of being started without risk of failure due to thermal shock.~~:

(a) capable of being started in a hot condition without risk of failure due to thermal shock. This is to be demonstrated by means of submitting test reports for the materials of construction which provide evidence that the materials can accommodate the thermal stresses associated with hot starting; or
(b) provided with a soft start which prevents thermal shock. This may be achieved by means of a by-pass arrangement or by means of water flow control.

■ *Section 7*
Pumping and piping

7.1 General

7.1.1 Pipe work and transfer systems which may carry chemical substances are to meet the requirements of ~~Ch 5 Cargo Transfer of the Rules for Ships for Liquid Chemicals~~ Vol 2, Pt 7, Ch 1 Piping Design Requirements, Ch 2 Ship Piping System and Ch 3 Machinery Piping Systems, as applicable. Lining steel pipe systems with corrosion-resistant materials is subject to special approval. The elasticity of the lining is not to be less than that of the supporting boundary material.

7.1.3 Chemical transfer and control arrangements are ~~to meet the requirements of Ch 5, 6 Cargo transfer control systems of the Rules for Ships for Liquid Chemicals.~~ to be provided with one stop-valve capable of being manually operated on each tank filling and discharge line, located near the tank penetration, plus one stop valve at each chemical-hose loading connection. The stop valve for the chemical tank discharge line is additionally to the quick closing type and is to meet the requirements of Vol 2, Pt 12, Ch 1, 9.1.6.

7.1.7 ~~Piping systems carrying chemical substances or effluents and by-products are to meet the requirements of Ch 6 Materials of Construction and welding of the Rules for Ships for Liquid Chemicals. This requirement includes exhaust piping where such substances are injected into exhaust gas or where the exhaust gas passes through a liquid scrubber which uses chemical substances.~~ Where chemicals or wash water are injected into exhaust piping then the exhaust piping is to be suitable for such chemicals and wash water, *see* Vol 2, Pt 12, Ch 1, 3.3.1.

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